FREE ISSUE

BULLETIN No. 123

DISEASES OF VEGETABLES

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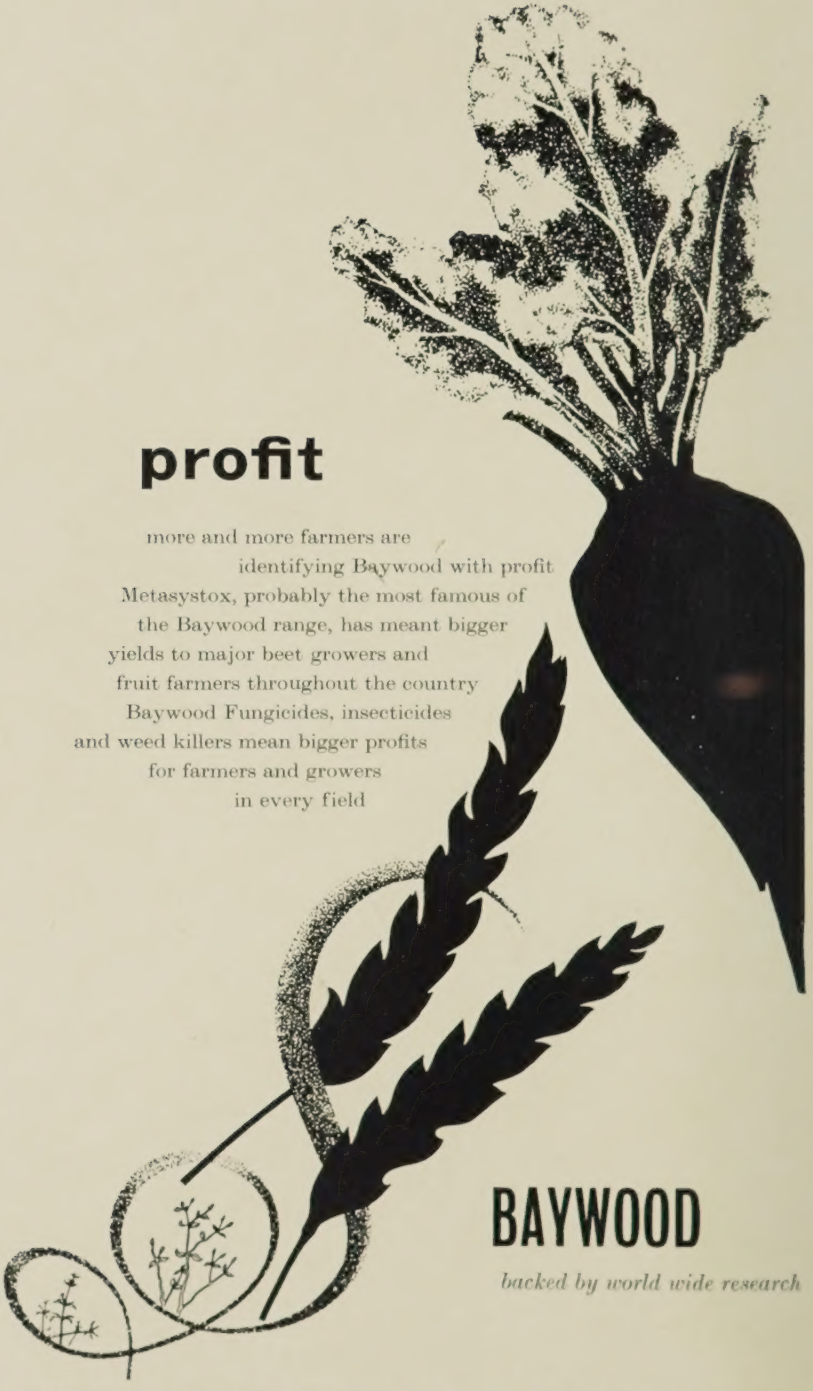

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MINISTRY OF
AGRICULTURE, FISHERIES AND FOOD

Diseases of Vegetables

LAWRENCE OGILVIE, M.A., M.Sc.
Plant Pathologist, South Western Region,
National Agricultural Advisory Service

Bulletin No. 123

LONDON
HER MAJESTY'S STATIONERY OFFICE
1961

First published, July, 1941
Fifth edition, February, 1961

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Foreword

THIS bulletin really needs no introduction for it is already very widely known. When it was first issued in 1941 Mr. Ogilvie was the recognized expert on diseases of vegetables in this country. He had made a special study of them for many years in his capacity as an advisory plant pathologist stationed at the Long Ashton Research Station, and he was also in charge of a field research station that had been established in the Vale of Evesham primarily to investigate the problems of the vegetable grower. He knew what the grower wanted and therefore placed most emphasis on the recognition and control of the many different diseases, and the effect of cultural practices on them. The bulletin was well received at a time when maximum production was all important. It was reprinted twice in the first year and has since run through several revised editions. In this, the fifth edition, the original pattern is still retained, and both growers and advisers are presented with a very practical and up-to-date account of all the diseases they are likely to meet with in the cultivation of vegetables.

W. C. MOORE,

Director, Plant Pathology Laboratory.

December, 1960.

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Introduction

It should not be difficult for the grower to recognize most of the diseases dealt with in this Bulletin if he examines the diseased plants carefully, and compares the symptoms with those described in the appropriate section. Proper recognition of diseases is very important if the correct control measures are to be employed. Where there is the slightest doubt about identification it is advisable to consult the County Horticultural Officer of the National Agricultural Advisory Service and through him, if necessary, one of the Regional Advisory Plant Pathologists who are always ready to give free advice to growers on all matters connected with plant diseases.

Kinds of Disease

Most plant diseases are caused by fungi, by bacteria or by viruses, although rather similar symptoms may sometimes be brought about by defects in nutrition or errors in cultivation.

The fungi, or parasitic moulds, which cause plant disease are usually so small that they can be seen only with the aid of a magnifying glass or a microscope. Some can attack only one kind of plant, others a whole range of different kinds of plants. Most reproduce themselves by minute spores or seed-like bodies, which are often distributed by wind or water, while some have thick-walled resting spores which can survive for a long time in decayed parts of plants, in the soil, or on seeds, so carrying the fungus over from one growing season to another.

Bacterial diseases of plants are not so numerous as those caused by fungi, and relatively few affect vegetables in England. The bacteria causing them are microscopic and similar in structure to those causing many human diseases; none of the bacteria causing diseases of plants, however, is in any way harmful to man.

Virus diseases are now known on most crop plants. The viruses which cause them are extremely minute, being invisible under the highest powers of the optical microscope; their shape and size can be determined, however, by means of the electron microscope. The virus usually penetrates all parts of a plant, causing mottling of the normal green colour, distortion of leaves or stems and sometimes withering or death of parts of the plants. Diseased plants seldom recover, although symptoms may sometimes be masked if plants are grown at abnormally high or low temperatures, or under optimum conditions of manuring.

Many virus diseases are very infectious. Some can be transmitted from plant to plant by touch, but others are transmitted only by insects, usually aphids or greenflies, and in some instances thrips, beetles or other insects. Others are carried in, or less often on, the surface of seeds. Some can persist for a long time in dried plant material. The virus of tobacco mosaic, for example, is often present in cured tobacco, and tomato plants may be infected by contamination from the hands of workers who smoke. The virus of tobacco mosaic may also persist for some months in infected plant material in the soil, and infect young seedlings when they are planted out, and other viruses may be transmitted from the soil.

General poor growth, or more definite and characteristic injuries to plants may also be caused by deficiencies or excesses of certain nutrient substances or chemicals in the soil, by fumes in the air, by drought or by excess of water, by faulty cultivation, etc. Sometimes one or other of these factors may be the real cause underlying an epidemic of a fungus disease, the fungus epidemic thus being merely secondary.

Disease Prevention and Control

The measures suggested for the prevention and control of diseases are often those employed as a matter of course by the good grower. These include the use of "clean" seed of vigorous and suitable varieties, satisfactory drainage, thorough cultivation, balanced use of fertilizers, carefully chosen rotations which will ensure that disease residues disappear from the soil, and avoiding overcrowding the plants.

Plant hygiene is also very important in disease control. This includes such measures as prompt removal and burning of diseased plants and, in some cases, of neighbouring weeds or "volunteer" plants if they are known to harbour a disease.

Finally there are more direct measures for the prevention and control of disease, such as soil sterilization, seed disinfection and the application of sprays or dusts (see p. 83).

Diseases of Particular Vegetable Crops

CABBAGE, CAULIFLOWER, ETC.

Club Root

Practically all vegetables of the cabbage family, such as turnip, swede, kohlrabi, rape, cabbage, broccoli, cauliflower, Brussels sprouts, radish and mustard, and some ornamental cruciferous plants, such as wallflower, stock and candytuft, and cruciferous weeds, including charlock, runch and shepherd's purse are affected by club root* (*Plasmodiophora brassicae* Woron.). Several non-cruciferous crops can become slightly infected, but without much practical consequence.

The disease is caused by a fungus which enters the root system of the plants from the soil. Rounded or spindle-shaped swellings develop on the roots or at the base of the stem, and may become quite large and irregular. When cut across they have a mottled appearance inside and eventually decay in a bad-smelling soft rot. As they disintegrate many thousands of resting spores of the fungus are liberated into the soil, and remain alive there for several years.

Affected seedlings make very little growth. If the plants are attacked at a later stage, the stunting effect is not so marked, but the plants may wilt or appear sickly, with discoloured leaves.

* See Advisory Leaflet No. 276.

The Appendix on p. 97 contains a full list of Ministry of Agriculture publications on vegetable diseases and related matters.

The galls or swellings produced on the roots and stem bases by the turnip gall weevil* are sometimes mistaken for club root, but they can be distinguished by cutting them through, for they are hollow and usually contain the maggot of the weevil. Again, considerable thickening of the stems and stem bases, with gall formation, may be caused by 2,4–D and MCPA weedkillers.

Although the disease is often associated with soil acidity, club root can develop quite readily in heavily contaminated soils of pH up to about 8·0 in circumstances otherwise conducive to it.

Control

Satisfactory control of the disease can usually be obtained by applying lime to the soil. An Advisory Soil Chemist of the N.A.A.S. should be consulted, since in some soils mineral deficiency symptoms in other crops may be induced by heavy applications of lime. Control is best achieved by applying powdered hydrated lime at a rate designed to bring the soil approximately to the neutral point, plus an additional 1,000 lb per acre. Chalk or ground limestone may be used instead, but double these rates are required.

Two or three years may elapse before any strikingly beneficial results are apparent following the applications of lime. Where the disease is severe it is advisable to apply the lime immediately after removal of the infected crop and, if cruciferous crops are grown frequently, to continue the applications for several years in succession. It is most important to incorporate the lime well in the soil by thorough cultivation.

Liming, however, is not always successful in controlling the disease if the soil is heavily contaminated and soil moisture and temperature favour it. Consequently, other chemicals have been developed, for use especially on horticultural crops.

Seedlings should be raised in soil known to be free from the disease. Where there is any question of contamination the seedbed should be sterilized with 2 per cent formalin applied at the rate of about 2 gal per sq. yd at least a fortnight before sowing (p. 84).

When the seedlings are to be transplanted to their permanent quarters they, or the soil into which they are to be placed, should be treated with one or other of the following preparations of calomel (mercurous chloride) or corrosive sublimate (mercuric chloride). Both are also valuable in checking attacks by the cabbage root fly maggot.

Pure Calomel. Pure (100 per cent) calomel has given good results when used as a suspension in water. Two ounces of pure calomel are added to one pint of water, and the suspension is stirred vigorously. A handful (some 25 to 40) of the plants is treated at one time, the roots being dipped in the suspension and agitated well to ensure a good cover of the fungicide. They should then be put in the ground almost immediately. One pint of the suspension will treat 300 to 600 plants. Aldrin emulsion may be added to give more complete protection against cabbage root fly (4 c.c. of 30 per cent aldrin per pint).

4 per cent Calomel (Commercial Calomel Dust). The makers' recommendations are to put one heaped teaspoonful of 4 per cent calomel dust in each dibble hole, or to sprinkle it along a shallow drill and lightly rake it over before planting out. One pound of dust is required for every 50 plants.

* See Advisory Leaflet No. 196.

A widely used method is as follows. A thick paste is made up by mixing thoroughly 1 lb of 4 per cent calomel dust with ⅓ pt. (approx. 7 fl. oz) water. The seedlings are dipped in the paste, twelve at a time, so that their roots become thoroughly coated with the mixture, and are then planted out. The paste should be made up in a wooden or earthenware container. One pound of 4 per cent dust is sufficient for treating 100 plants.

This method is sometimes followed by a check to the plants, especially in dry weather, apparently owing to the thick paste drying on the roots, and is more expensive than the pure calomel method.

Corrosive Sublimate. The corrosive sublimate (mercuric chloride) method gives good results, but much care must be taken on account of the very poisonous nature of the chemical. One ounce of corrosive sublimate should be dissolved in 12½ gal of water. This gives a solution of 1 part in 2,000 of water. The small grower can obtain the substance from a chemist in the form of tablets, each containing 8¾ grains. One tablet is dissolved in a little boiling water, which is then made up to one quart to give the required strength. In each case the solution must be prepared in a glass, china, plastic or earthenware vessel. Vessels which have contained the solution must be washed well after use, and the chemicals should be kept locked up. The solution should be watered twice into each dibble hole at the rate of ¼ pint per time. The plant is then inserted and the hole closed in the usual manner.

Although this method is equal in effectiveness to the pure calomel method, its drawbacks are the poisonous nature of the chemical, and the time and labour involved in treating individual plants.

Quintozene (*Pentachloronitrobenzene*). This material has had some vogue in the prevention of club root in the U.S.A. A 75 per cent wettable formulation at 2, 4 or 8 lb per 100 gal is applied to the seedlings at ½ pt. per plant at the time of transplanting. An English preparation, a powder containing 20 per cent quintozene, has been suggested at the rate of ½ oz per sq. yd (1½ cwt per acre), preferably mixed with the soil a few days before planting. This chemical is most likely to be successful where the disease is not very severe.

In experiments carried out in England it has been found difficult to devise a concentration and method of application of quintozene which is effective and which will not cause injury to the plants.

In addition to these direct measures of combating club root, there are various important indirect methods. Since it spreads most rapidly in wet seasons and on badly drained soils, faulty drainage should be rectified. Acid fertilizers, such as superphosphate, dissolved bones and sulphate of ammonia, should be avoided, and basic slag, nitrate of soda and nitrate of lime should be given instead. Diseased plants should be burned, and not be left in the soil or incorporated in compost heaps. In gardens and allotments it is advisable to pull up and burn diseased plants before the root swellings begin to decay.

The resting spores of the club root organism may remain alive in the soil for seven years or longer. Where the disease is troublesome, therefore, an effort should be made to rotate crops so that plants of the cabbage family are not grown on the same ground more often than once in six or seven years. Cruciferous weeds should be kept down.

The disease does not develop so readily during the winter, and it is often possible to grow susceptible crops successfully on contaminated land if these

are planted late enough in the season. Thus autumn planted spring cabbage, or glasshouse-raised cauliflowers, put out in early spring, may be less affected by club root than summer cabbage or autumn cauliflowers.

Cauliflowers are very susceptible to the disease. There are no really resistant varieties of cabbage, cauliflower, broccoli and Brussels sprouts, but marrowstem kale is often less severely attacked than other brassicae, while some strains of kohlrabi are rather resistant. There are several races affecting brassicas, which complicates breeding for resistance.

Under the Sale of Diseased Plants (Amendment) Order of 1941 and the Sale of Diseased Plants (Scotland) (Amendment) Order of 1941, plants substantially affected with club root may not be sold for planting purposes.

Canker

Canker (*Phoma lingam* (Fr.) Desm.), which is also referred to as "black leg" in America, is sometimes found on cabbage, kale, Brussels sprouts, cauliflower and broccoli in England, especially in the Northern counties (see Dry Rot of Swede, p. 14). It is not uncommon on broccoli kept for seed.

Seed is sometimes infected and the first signs of disease may occur on the seed-leaves. The fungus may then attack the stem, leaves, flowering stalk, seed-capsule and finally the seeds again. The most noticeable damage is done to the stem. Light brown or purplish cankers appear on the stem base and tap root and the tissues finally turn black and the roots decay. The plant remains stunted and may finally wilt. Minute black fruiting bodies (pycnidia) of the fungus are produced on the diseased areas. The leaf spots may be distinguished from those of ring spot (described on p. 6) by their fewer and larger pustules, borne on well defined spots with ashen-grey centres.

There are several strains of the fungus and those affecting cabbage and swede respectively may be distinct.

Control

The seedbed should be prepared on soil which has not carried brassicas for several years. All diseased refuse should be burnt. Cabbages and related crops should not be planted in the same field more than once in four years.

A report on the amount of *Phoma* infection in a seed sample can be obtained from the Official Seed Testing Station, Huntingdon Road, Cambridge, on payment of a fee of 15*s*.

Where infection with canker is suspected, the seed may be treated by placing it in a cheese-cloth sack and immersing it in water accurately maintained at 122°F for 15 to 30 minutes.* It is then placed in cold water, drained and spread in a thin layer to dry. As the treatment may impair germination in some samples of seed, it is advisable to run a preliminary test on a small quantity of seed. Plants grown for seed production should be well isolated and raised from treated seed.

Verticillium Wilt

Verticillium wilt (*Verticillium dahliae* Kleb.) affects Brussels sprouts. The fungus penetrates the wood vessels of the plants, which become dark brown

* See leaflet: *Hot-Water Treatment of Celery and Broccoli Seed*, obtainable from the Ministry of Agriculture, Fisheries and Food (Publications), Ruskin Av., Kew, Richmond, Surrey.

or black. The lower leaves are the first to show symptoms, interveinal areas becoming pale green, yellow and finally brown, and the leaves withering and dropping off. These symptoms often affect one side of the leaf or of the plant. The outer leaves of the sprouts are usually similarly discoloured. The disease is not seed-borne.

Control

Affected plants should be burned and a rotation planned with resistant crops, such as runner beans, cauliflower or broccoli. Machinery should be cleaned before it is moved to other fields. The disease is often associated with wet soils.

Black Rot

In this country black rot (*Xanthomonas campestris* (Pamm.) Dowson), is not a serious disease but is sometimes found on kale, cabbage and cauliflower. It is liable to be troublesome only in very warm and moist summers.

The symptoms are a yellowing of the leaves, usually beginning at the tips, accompanied by blackening of the veins. A characteristic black ring can be seen when the stalks of diseased plants are cut across. This is caused by invasion of the water-conducting strands by the bacteria. Affected seedlings are killed or seriously checked, while in older plants the development of the head may be prevented and the tissues may be invaded by secondary soft rot bacteria. The disease is nearly always seed-borne, and infection of seedlings and contamination of soil follows.

Control

Where the disease has occurred, infected material should be burned, and cruciferous plants should not be grown on the same soil for two or three years. Where seed infection is suspected, the hot-water treatment described under canker may be employed.

Ring Spot

Ring spot (*Mycosphaerella brassicicola* (Duby) Oudem.) is found chiefly on broccoli, Brussels sprouts, cabbage and savoys, mainly in the south and south-west of the country, during wet weather in the winter. It is commonest where these crops are grown on the same ground year after year and in gardens that have been manured heavily.

More or less circular brown spots, up to $\frac{1}{2}$ in. in diameter, are formed on the foliage, stems and seed pods, and are most abundant on the outer and lower leaves. The surface of these spots is dotted over with the minute black fruiting pustules of the fungus arranged in concentric rings. Diseased leaves become yellow and wither off prematurely.

The fungus may infect the seeds, but the importance of seed infection is not known. The chief sources of infection are the remains of diseased leaves persisting in the soil, from which spores are shot off, and mature Brassicas near younger crops.

Control

Where this disease is severe it is advisable to isolate the seedbed, to practise a rotation of the crops, to burn diseased refuse and to see that where growth is excessive, sulphate or muriate of potash is applied at the rate of 2–3 cwt per acre. The Roscoff strains of broccoli are markedly resistant and several commercial strains less so.

Other Leaf Spots

These are less important and do not usually require control measures. *Gloeosporium concentricum* (Fr.) Berk. & Br. forms roundish pale spots on the leaves of cabbages, cauliflowers, broccoli and Brussels sprouts. These may eventually coalesce to produce dead patches, usually confined to the lower leaves. *Alternaria brassicae* (Berk.) Sacc. and *A. brassicicola* (Schwein.) Wiltshire, cause rather large zonate black spots on the leaves, and the former is reported to produce a brown decay of cauliflower curd. *A. brassicicola* can cause blackening of the stems and pods of seed crops. The use of a colloidal copper spray with a spreader is recommended. It is also commonly found on broccoli seed and induces decay of seedlings. A hot water treatment (122°F for 25 min), as advised for canker, has been found to prevent its development and to eliminate diseased and weakly seedlings. Powdery mildew (*Erysiphe polygoni* DC.) is very occasional on cabbage and Brussels sprouts.

Soft Rot

Soft rot (*Pectobacterium carotovorum* (L. R. Jones) Waldee and other bacteria) may cause considerable damage to cauliflower, broccoli and kale. The soft internal tissues of the stem may disintegrate, reducing it to a bad-smelling slimy mass. The margins of the leaves may also rot. In broccoli the curds or flowers may show brown discoloured patches, resembling frost injury, which make them useless for market. Seed production may be completely prevented.

Control

Soft rot often accompanies mineral deficiency symptoms. Potassium deficiency (p. 12) or an unbalance of potassium and other essential chemicals may bring about marginal leaf-scorching and winter killing which may be followed by bacterial attack, while boron deficiency (p. 13) may be followed by swelling and internal splitting of the stem and softening of the tissues. Hollow stem without rotting, however, is usually due to nitrogen-potash unbalance. Soft rots are also common where an excess of farmyard manure is applied on poorly drained land.

Rotation of crops should be practised.

Bacterial Spot

Bacterial spot (*Pseudomonas maculicola* (McCull.) Stev.) is well known on cauliflower in America and may occur in England. The leaves are covered with small brown or purplish spots varying in size from mere points to $\frac{1}{8}$ in. in diameter. These usually originate at the stomata or breathing pores, mainly on the lower surface of the leaf, and may coalesce into larger irregular blotches.* Badly diseased leaves may be distorted and finally turn yellow and drop off.

Small brown or dark brown spots may appear on the curd. These vary in size, sometimes attaining a diameter of about $\frac{1}{4}$ in.; at first they are firm but later become soft. They are confined to the surface layers of the curd and seldom penetrate to the deeper tissues, but as the disease progresses they become invaded by secondary organisms and rot sets in. The disease appears to occur especially on over-mature curd, after frost damage, or during cool wet weather. It should be noted that a similar curd spotting, without accom-

* Small dead spots on the leaves can also be produced by cauliflower mosaic and cabbage black ringspot.

panying bacteria, is found sporadically throughout the country, especially on certain varieties of cauliflower, and may be associated with nitrogenous conditions, over-maturity, and weather.

Control

Destruction of diseased refuse and adequate rotation of crops is suggested The heads should not be allowed to become over-mature.

Downy Mildew

Downy mildew (*Peronospora parasitica* (Fr.) Tul.) is a very common disease of brassica crops. It is especially troublesome on cauliflower seedlings when they have been exposed to excessive moisture or to drips from the roof while being raised in glasshouses or frames. Infection first appears on the seed leaves. The foliage of diseased seedlings becomes speckled with yellow, and on the under surface of the leaves white downy patches of the fungus can be seen (Plate I, upper). Badly infected seedlings may be stunted or killed.

Symptoms of the disease on mature plants in the field are ill-defined yellowish brown areas between the main veins, on the under surfaces of which a white downy mould appears in moist weather. Severely infected leaves become yellow and die off, while soft rot organisms may attack the plant secondarily.

Control

Care should be taken to give abundant ventilation to seedlings growing in frames or glasshouses. There should be no drip from the glass and the frames should be closed during heavy rainstorms. Seedlings should not be too crowded. The deliberate check given to pot-grown cauliflower seedlings to prevent them from becoming too big before planting out is often associated with downy mildew attack. In the open, seedlings tend to outgrow the disease if they are top dressed with a nitrogenous fertilizer.

Early treatment with Bordeaux mixture or a similar copper compound, or with copper lime dust is usually effective in controlling the disease on seedlings. Both zineb and streptomycin, the latter at 50 or 100 p.p.m., have also given good results in trials in the U.S.A.

Downy mildew tends to become prevalent, late in the season, on the outer leaves of broccoli and cauliflower suffering from deficiencies of potash and magnesium. Similarly to *Alternaria brassicicola*, it also appears to be responsible for discolouring the "buttons" of Brussels sprouts, although some varieties seem to be more resistant than others.

White Blister

Both seedlings and older plants may be attacked by white blister (*Cystopus candidus* (Pers. ex Chev.) Lév.). White patches, at first smooth and glossy as porcelain but later powdery in appearance, appear mainly on the undersides of the leaves (Plate I, lower), or on stems and inflorescences, sometimes in association with downy mildew. Occasionally the hearts of cabbages may be destroyed or the curds of cauliflowers considerably distorted.

Control

Seedbeds should occupy a dry open situation. Diseased plants should be burned. The forms of the fungus on cruciferous weeds, such as shepherd's purse, are usually distinct.

Grey Mould

Grey mould (*Botrytis cinerea* Fr.) may attack the sprouts of Brussels sprouts and the hearts of cabbages, which become soft and eventually covered with a grey fungus growth. In the sprouts the trouble is usually associated with decay of a broken leaf-stalk immediately adjacent. Where the attack is widespread the nitrogen-potash balance has usually been upset by heavy nitrogenous manuring. In cabbages, frost injury is often the predisposing factor, though potash deficiency may again be implicated.

Damping-off and Wire Stem

Damping-off of seedlings and wire stem of older plants of cabbage, cauliflower and kale is caused by the fungus *Corticium solani* (Prill. & Delacr.) Bourd. & Galz*. In damping-off, the stems of the seedlings are softened and collapse at ground level. In wire stem, due to attack at a later stage or where the environment is unfavourable to the fungus, the bases of the stems are hard, brown and shrunken (Plate 00). The roots become so badly affected that the plants die, or the hard constriction of the stems may persist so that affected plants may be broken off easily at a later stage.

Control

When the trouble is found in glasshouses, for instance on cauliflower seedlings, it is usually associated with wet spots such as those caused by drip from the roofs. Rotation of crops and hygienic disposal of refuse are recommended. Soil for raising seedlings under glass should be sterilized by formalin or steaming (pp. 83 and 84). Growers in some of the early cauliflower areas water the glasshouse soil, one or two days before sowing the seed, with mercuric chloride (deadly poisonous, see p. 92) at 1 oz in 12½ gal of water, applied at 1 gal per sq. yd. Some control can be got by watering the seedlings with mercuric chloride at 1 oz per 15 gal of water. The mercuric chloride may be difficult to dissolve even in hot water; in this case an equal weight of common salt may be added. Quintozene (pentachloronitrobenzene) has also given good results, incorporated with the soil before sowing, at 1 oz per sq. yd of a 20 per cent dust.

Root Rot

Brassica crops of various kinds in damp and waterlogged situations may be infected with a root rot caused by the fungus *Phytophthora megasperma* Dresch. The cortex of the stem and roots sloughs off readily and the lower leaves become discoloured and wilt.

Whiptail

Whiptail in broccoli and cauliflower (Plate X) is caused by molybdenum deficiency, due to lack of available molybdenum in the soil. Typical symptoms are malformation of the leaves, which become whip-like or strap-like, with much reduced, ruffled or irregular leaf blades. The growing points may be stunted or stub-like, or even become blind. If the curd develops at all, it is undersized, with small leaves growing through it. Another symptom is yellowing and inward cupping of the leaves of seedlings.

Control

Molybdenum deficiency occurs most commonly on acid soils, of varied geological origin, and is accentuated by dry weather. It can be prevented by

* = *Rhizoctonia solani.*

application of lime to the soil, to bring it nearly to the neutral point, molybdenum being thereby made available to the plants. As an extra precaution, or if the ground cannot be limed, a solution of ammonium molybdate, at the rate of 1 oz dissolved in 1–2 gal of water per 10 sq. yd, should be applied to the soil of the seedbed after the seedlings have appeared above ground.

On holdings where whiptail has been observed, it is a common practice to mix sodium molybdate with the aldrin used to control cabbage root fly. The recommendations are as follows:

1. (*a*) Make up a stock solution by dissolving 4 oz sodium molybdate in 1 pt of hot water.

   (*b*) Add 2½ fl. oz of sodium molybdate stock solution and 2 fl. oz 30 per cent aldrin miscible oil *or* 3 fl. oz 15 per cent dieldrin miscible oil to 10 gal water. Stir well before using.

2. For larger quantities use 5 oz sodium molybdate with either 1 pt 30 per cent aldrin concentrate *or* 1¾ pt 15 per cent dieldrin concentrate in 100 gal water. The sodium molybdate crystals should be first dissolved in a small quantity (say 2 pt) of hot water and then added to the diluted insecticide solution and thoroughly stirred.

The combined sodium molybdate and aldrin or dieldrin should be applied to the plants in pots a few days before planting out. Approximately $\frac{1}{16}$ pt. should be applied to each pot, using a watering can with a fine rose.

Very similar symptoms sometimes occur in cauliflower on neutral soils and may be produced by a check, due to low temperature, drought, etc., in the early stages of growth, e.g., when cold weather is experienced after seedlings have been put out from under glass, or following excessive use of quick-acting forms of nitrogen. Management to encourage even and undisturbed growth should be aimed at. No curative methods can be suggested, but it may be noted that affected plants often recover.

Attack by the swede midge (*Contarinia nasturtii* Kieff.) may also produce symptoms resembling those described above.

Cauliflower Mosaic

Cauliflower mosaic* occurs on cauliflower and broccoli and other brassicas in areas where these crops are concentrated, though the disease is less prevalent than it was immediately after World War II. The first sign of infection is a pronounced clearing of the veins towards the bases of the younger leaves. This changes gradually to vein banding: pale chlorotic areas appear between the veins, while immediately adjoining the latter are well-defined bands of dark green. Occasionally the veins are banded with light green and the interveinal areas dark green. The interveinal areas are often broken by spots, rings or blotches of lighter or darker green. Many varieties of cauliflower also develop necrotic (dead) spots varying from minute specks to areas 3 mm in diameter. These are well seen in cabbage and are referred to as "stipple".

Symptom expression depends largely on variety and on the vigour of the plant. Symptoms may be obscured when growth is slow during the winter or because of shortage of fertilizer and also during periods of extreme heat. In winter the outer leaves of diseased plants may be shed, giving a "palm-tree" effect and the plants may even die off.

Some varieties of cauliflower are more tolerant to the disease than others, and show few symptoms. In intolerant varieties the disease causes dwarfing of

* See Advisory Leaflet No. 370.

the plants and reduction in the size of the curd, which may be discoloured and more liable to frost injury than in healthy plants. The disease also affects Brussels sprouts, kale and cabbage, sprouting broccoli, etc., but in these there is less reduction of crop.

Control

There is no evidence of seed transmission, and the disease is apparently carried over throughout the year on brassica crops of one kind or another, and possibly also in certain cruciferous weeds and ornamentals. It can be transmitted from these to brassica seedbeds by greenflies, such as the cabbage aphid, *Brevicoryne brassicae*, and by *Myzus persicae*. Suggested means of control are therefore isolation of seedbeds, which should be some distance away from mature crops of brassicas, and not adjacent to hedges, trees or buildings. It may be advantageous to surround the seedbed with an early sown barrier of one to three rows of barley. Other important measures are rotation; adequate separation of successive plantings; clean cultivation; and roguing (removal of diseased plants) early in the season. The value of spraying for the control of the aphids is doubtful.

Cabbage Black Ringspot

On cabbage the virus produces small black rings or spots which may be sufficiently numerous to cover the leaf. On cauliflower there are chlorotic or necrotic spots or rings, usually discrete and raised slightly to form blisters, and lacking the waxy bloom of the rest of the leaf. Symptoms appear first on the youngest leaves but later are confined to the lower leaves. A common disease of stocks and wallflowers, of which the symptoms are mottling of the leaves and "breaking" of the flowers, may be caused by the same virus.

The disease is not so injurious as cauliflower mosaic to cauliflower, but, where epidemic, can cause serious damage to cabbage. It is not transmitted in the seed and the control measures suggested are similar to those recommended for cauliflower mosaic.

Turnip Yellow Mosaic

A strain of turnip yellow mosaic virus (see p. 16), at present confined to north-east England, can cause severe losses of broccoli, cauliflower, cabbage and other brassicas. The plants are stunted and the leaves are covered with irregular yellow blotches, become necrotic, and fall prematurely. Broccoli infected in the autumn may be killed in the winter or fail to produce marketable curds. Plants infected in spring produce heads of poor quality.

Isolation of seedbeds and vigorous control of flea-beetles, which transmit the virus, are recommended in the early stages of growth.

Scorch

Scorch is found on winter cauliflower and broccoli under mild humid conditions. The heart leaves become stunted or truncated and brown at their tips, or may die off entirely. The curd is reduced in size and may break down with secondary bacterial rot. Scorch plants are liable to frost damage. Symptoms develop some two or three months after planting and reach their maximum at time of heading.

Scorch appears to be an inherited character, the expression of which is intensified by high levels of nitrogenous manuring. It is recommended that

only scorch-free plants should be grown on for mother seed. A more stringent precaution would be to self selected mother plants and to use for mother seed production only those families which are scorch-free when grown under heavy nitrogenous manuring.

Potassium Deficiency

Symptoms of potassium deficiency* are very characteristic on most brassica crops. Cabbages show a bluish green coloration with subsequent yellowing and scorching of the leaf margins, accompanied by poor hearting. Brussels sprouts show similar leaf symptoms, with looseness and poor development of the sprouts. Kale and cauliflower show yellowing and a marginal leaf scorch, cauliflower producing a poor and irregular curd. Savoys, on the other hand, appear to grow well even where there is a deficiency of potash.

Potassium deficiency symptoms are liable to occur on land recently broken up from grass, on light soils with naturally low potassium content, on shallow soils with impervious subsoils, on heavy soils with deficient drainage, and in gardens richly manured with nitrogenous materials, where the balance or nutrient ratio between nitrogen and potassium has been upset.

There is evidence that potash deficiency renders the plants more liable to frost damage and to attack by downy mildew, grey mould, and soft rot, as well as by the cabbage aphid.

Potassium deficiency symptoms resemble to some extent those of attack by the cabbage root fly, *Erioischia brassicae*. In the latter, however, besides showing discoloration of the leaves, the plants become limp and flaccid and their stem bases and roots are tunnelled by maggots.

Manurial practices vary with the crop and the soil, but where the vegetables are being grown in a rotation, 2 to 4 cwt sulphate of potash applied annually, when the land is being prepared for planting, should suffice. If muriate of potash is used instead, it should be applied several weeks before seed sowing or planting to avoid risk of damage.

Magnesium Deficiency

The symptoms of magnesium deficiency on cabbage, cauliflower, etc., are pale marbled areas between the veins, sometimes accompanied by purpling of the leaves. The pale areas finally dry out into brown dead patches. Growth and maturity may be greatly checked and the plants may become badly attacked by downy mildew.

Deficiency of available magnesium may occur both on acid soils and on soils containing ample supplies of lime, especially where this has been added. It is most prevalent on light soils under conditions where the magnesium is readily leached away, as in wet seasons. The deficiency may become apparent after several years of routine manuring with inorganic fertilizers, especially where an original potassium deficiency has been overcome by the application of liberal amounts of potash.

Control

In acid soils the deficiency may be counteracted by applying a high-grade magnesium limestone at the rate of about 1 ton per acre. In soils containing

* The symptoms of mineral deficiencies in crop plants are described and illustrated in *The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms: a Colour Atlas and Guide*, by Prof. T. Wallace, C.B.E. Published by H.M. Stationery Office. New edition in prep.

lime, magnesium sulphate (calcined kieserite or Epsom salts) or sulphate of potash magnesia may be used at the rate of about 1 to 4 cwt per acre. Magnesium sulphate should preferably be applied just before the plants are set out in the ground. In its place magnesian limestone may be applied in small quantities or incorporated with fertilizers, such as superphosphate and ammonium sulphate.

The turning-in of crop residues or of green manures and the use of farmyard manure also tend to preserve supplies of magnesium in the soil.

Boron Deficiency

On cauliflower, a deficiency of available boron in the soil can lead to stunting and deformation of the leaves immediately surrounding the curd, considerable reduction in size of curd, and the appearance of brownish water-soaked areas on its surface. The brown areas extend down the inside of the flower branches into the upper part of the main stem. The affected head has a bitter flavour, both when it is raw and cooked. Stems and head are liable to be invaded by soft rot bacteria (p. 7). The stems of kale are similarly affected. Hollowness of the stems, without rotting, is usually due to a nitrogen-potash unbalance.

Control

Applications of borax at the rate of 10 lb per acre, broadcast with the fertilizer and harrowed in before planting, have controlled the brown rot symptoms. Applications of borax in solution at 18 lb per acre, when the first sign of internal browning was recorded, prevented further development of the trouble. For recommendations concerning the application of borax to soils see heart rot of beet (p. 22). The Horticultural Advisory Officers should be asked, however, to confirm the provisional diagnosis before any action is taken.

TURNIP AND SWEDE

Club Root

Club root* (*Plasmodiophora brassicae* Woron.) has been mentioned already on p. 2. On swede and turnip the parasite induces tumour-like swellings and the main bulb or root may be very distorted (Plate IV). When the swellings are cut through, the flesh inside is seen to be mottled. Diseased roots decay prematurely and finally disappear in a pulpy putrid mass. The trouble should be distinguished from damage caused by the turnip gall weevil.†

Control

The parasite may remain in the ground for seven years or more, a fact which should be borne in mind in planning rotations of garden vegetables. In farm practice it is advisable to omit swedes and turnips from the four-course rotation after a diseased crop, and to replace them by potatoes or mangolds. Diseased roots should be fed off to stock on the spot, or, if this is not possible, on a permanent pasture. Drainage should be attended to if necessary.

* See Advisory Leaflet No. 276.
† See Advisory Leaflet No. 196.

Applications of lime as already recommended (p. 12) to produce an alkalinity above neutral (pH 7.0), will usually bring about satisfactory control. Thorough tillage, to incorporate the lime in the soil, appears to be very important. Basic fertilizers should be preferred to acid ones.

Some resistant varieties of swedes have been introduced from Denmark, such as 'Studsgaard,' 'Bangholm' and 'Wilhelmsburger'. The last named is superior in crop production, and is also resistant to dry rot and root rot. It is however susceptible to some strains of club root.

Among turnips, 'Dale's Hybrid' is claimed to be resistant on the Continent, as is also 'Irvine's Green Top Yellow'. The yellow fleshed, purple-topped Scots variety, 'The Bruce,' and its selection, 'The Wallace,' have been stated to be highly resistant, but the former has not always lived up to its reputation, and is, moreover, in company with 'Dale's Hybrid,' rather susceptible to soft rot and leaf spot. It is difficult to secure genuine seed, and a guarantee should be requested. The soft white-fleshed turnips are, in general, more susceptible than yellow-fleshed ones. Marrowstem kale is often less severely attacked than other brassica crops and is useful where turnips and swedes are apt to fail. There is some evidence that the club root organism may occasionally be carried on the surface of swede seed.

Dry Rot

Turnips and swedes are attacked by dry rot (*Phoma lingam* (Fr.) Desm.), but swedes are usually the more severely affected. During the autumn, more or less circular areas of rotted plants may be found in the fields, with the worst ones in the centre. The disease also spreads in storage, where it may cause much loss. The first symptom on the "root" or "bulb" is a light-coloured transversely elongated spot. This affected area, which gradually changes from dark green to light brown in colour as it enlarges, becomes sunken and eventually splits so that a transverse crack appears across the surface of the root. At the same time minute dark pustules, in which the spores of the fungus are produced, are developed at the edges of the brown sunken area. Ultimately the whole root may break down with a brown dry rot, or the original cause of the disease may be masked by the development of a wet putrefaction.

Phoma lingam also frequently damages the swede seed-crop by attacking the plants at soil level, causing the condition known to growers as "canker". It attacks cabbages, etc., in the same way (p. 5). The fungus often causes ashen-grey spots with dark borders on the leaves of swedes, but these do not seem to be intimately connected with the dry rot phase, which appears rather to originate from the soil.

Control

The fungus which causes dry rot is seed-borne, probably both on and within the seed-coat, but the economic importance of this method of transmission is still a matter of opinion. Common sources of infection appear to be the soil, and manure contaminated with pieces of rotten roots. New Zealand work has shown that the fungus can produce a perfect stage (*Leptosphaeria* sp.) and spores from this may be wind-borne.

The fungus is likely to remain in the soil for several years in the absence of a turnip or swede crop. It is advisable, therefore, to allow adequate time

for the fungus to disappear before sowing another crop on infected soil, and to make sure that sites of successive turnip or swede crops do not overlap or adjoin. Since the fungus is able to attack the leaves of charlock, white mustard and runch (wild radish), these weeds should be kept down.

The chief method of control is to avoid the incorporation of pieces of diseased roots in compost heaps or manure. Debris from turnip or swede pits and manure from animals fed on an affected crop should be collected into a separate heap, and should not be put on fields likely to carry swedes or turnips in the near future.

It is advisable to grow varieties which usually succeed locally. There is some evidence that late-sown swedes are less susceptible than early-sown ones. Turnips are not usually as severely attacked as swedes, but this may be because they are sown later. Plants grown for seed should be subjected to rigorous inspection and selection.

Brown Heart

The yield of swedes does not appear to be affected by brown heart, known as "Raan" in Scotland, but it reduces the feeding value of swedes for stock and renders them unsuitable for human consumption.

In severe cases the leaves may be curled and brittle. Usually, however, there are no external symptoms. The leaves and root appear normal and the presence of the disease can be detected only by cutting open the root ("bulb"). Symptoms are first evident when the roots are about two inches in diameter, and become plainer as the season advances. In examining a root, a horizontal cut should be made a little below the middle and a vertical one down the centre. If the plant is affected by brown heart the cross-section will show a clearly defined zone near the centre, mottled with greyish or brownish glassy areas, often arranged in a concentric or radial formation. The diseased area is usually located in the lower two-thirds of the bulb, and in vertical section is elongated and converges towards the base. Diseased roots are bitter to the taste and woody when cooked.

Brown heart may be confused with frost injury, but in the latter the outside of the root is affected first.

Control

The trouble is caused by deficiency of boron in the soil in a form available to the plant. Like heart rot of beet, it is most common after dry seasons and in calcareous soils, or where lime has been applied. It may be prevented by applying borax to the soil at the rate of 20–40 lb per acre, about a week before sowing, as recommended for heart rot of beet (p. 22), or, if preferred, the required amount of borax can be incorporated with the general fertilizers and applied at the same time. If this early application has been omitted, one made as late as August may give beneficial results. Where heavy dressings of lime are made to control club root, an application of borax should be given as a precautionary measure. Green and bronze-topped swedes appear to suffer less than purple-topped sorts, while the varieties 'Superlative' and 'Wilhelmsburger' appear to be resistant to brown heart.

Soft Rot

Soft rot (*Pectobacterium carotovorum* (L. R. Jones) Waldee and other bacteria) is fairly common on swedes and turnips, especially in the north, and may

ruin a large percentage of roots in an affected crop. The heart or core of the bulb is converted into a white or grey soft putrid mass, while the outside often remains firm.

The rot usually enters through wounds caused by frost injury and during cultivation, or through roots infected with the dry rot fungus. It may also enter through crowns infested by larvae of the cabbage root fly*, by swede midge, by aphids, or by slugs, causing a form of damage that has been called crown rot. It is possible that swedes badly affected by mildew are more liable to soft rot, because the leaves tend to wilt badly and expose the crown. There is also a form of soft rot, referred to as root rot, which works up into the bulb from the roots. The disease is often found, too, in heavily manured and badly drained soil in gardens where little rotation is carried out. The club root resistant variety 'Wilhelmsburger' is unfortunately rather prone to soft rot owing to the spreading habit of its leaves, while the resistant hybrid turnips, 'Dale's Hybrid' and 'The Bruce', are also highly susceptible to soft rot and leaf spot. The varieties 'Tipperary' and 'Up-to-date' appear to be resistant to crown rot and root rot respectively.

Where the rotation is adequate, manuring is balanced and care is taken with the disposal of infected refuse, this disease need not be feared. Heavy liming is said to be a predisposing factor. Injuries to the plants while growing should be avoided.

Black Rot

Black rot (*Xanthomonas campestris* (Pamm.) Dowson) affects the leaves of turnips and swedes as it does those of cabbages, etc. It also invades the roots or bulbs of turnips and swedes, and turns them dark brown internally. They are then readily invaded by soft rot organisms and break down into a soft, bad-smelling mass. Control measures as for soft rot should be considered.

Mildew

Mildew (*Erysiphe polygoni* DC.) occurs commonly on turnips and swedes, but swedes suffer more severely. Late in the season, especially after dry summers, the leaves appear as if dusted with a fine white powder; in turnips this is usually confined to the lower surface.

In severe attacks the leaves are so badly crippled that they droop, and the growth of the plant is so checked that there may be a big reduction in yield. The roots may also crack around the crown, so that soft rot eventually develops. After October new leaves free from mildew are produced.

Control

The disease is favoured by light dry soils, while cultivation, by conserving moisture, tends to promote uniform growth and reduced susceptibility. In the warmer southern districts, early-sown crops are liable to be severely infected and seeding may be deferred until the end of June. There appear to be differences in the susceptibility of different varieties of both swedes and turnips. Among swedes, 'Improved Lord Derby' and 'Superlative' are resistant, while 'Magnum Bonum' is very susceptible.

Turnip Yellow Mosaic

In the virus disease turnip yellow mosaic there is at first a clearing of the veins of the youngest leaves. Then small yellow patches appear on the older

* See Advisory Leaflet No. 18.

leaves and these coalesce to give rise to larger yellow areas. The virus is not spread by aphids but by certain kinds of beetle, in particular the flea beetles, and by earwigs and grasshoppers. It occurs naturally on turnips, swedes, kale and broccoli (p. 11) and has been transmitted to other crucifers including weeds. Suggested methods of control are adequate rotations and clean cultivation.

Turnip Crinkle

Turnip crinkle is also transmitted by flea beetles. Severe infections cause vein clearing and distortion and crinkling, the plants being severely stunted and rosetted. The virus affects swedes, cauliflowers, Brussels sprouts and, in a mild fashion, cabbages. Some cruciferous weeds are badly distorted. Somewhat similar symptoms may be caused by cauliflower mosaic and cabbage black ringspot viruses (pp. 10 and 11).

Leaf Spot

Leaf spot (*Alternaria brassicae* (Berk.) Sacc.) is sometimes common on the leaves of hybrid turnips, such as 'Dale's Hybrid' and 'The Bruce'. The spots, which are pale brown, papery, about $\frac{1}{5}$ in. in diameter and each surrounded by a yellow halo, often coalesce and cause distortion and withering of parts of the leaf. Invasion of leaf stalks may lead to premature dying-off of the whole crown of the plant and to development of secondary soft rot of the bulb. The fungus is stated to be seed-borne and hot-water treatment of the seeds as described under canker (p. 5) has given satisfactory results in the U.S.A.

Violet Root Rot

Violet root rot* (*Helicobasidium purpureum* Pat.) which is sometimes found on swedes and turnips is described on p. 47. The same control measures should be adopted as for dry rot.

Downy Mildew

Downy mildew (*Peronospora parasitica* (Fr.) Tul.) may reduce the stand of seedling swedes by attacking the young leaves. It has also been observed on the pods of seed plants. Zineb has given some control of downy mildew in field swedes.

White Spot and White Blister

White spot (*Cercosporella brassicae* (Fautr. & Roum.) v. Hoehn.) and white blister (*Cystopus candidus* (Pers. ex Chev.) Lév.) are also found on swedes and turnips, but are of little economic importance.

SEAKALE

Black Rot

Black rot (*Xanthomonas campestris* (Pamm.) Dowson), which has been described for cabbage (p. 6), sometimes affects seakale, particularly when the drainage is faulty. For this reason, thorough drainage and sub-soiling should be carried out prior to planting. Any of the thongs used for propagation which show black streaks in the cut tissues should be discarded.

* See Advisory Leaflet No. 346.

Club Root

Seakale is affected by club root, but only where the lime content of the soil is very low (see p. 2).

Violet Root Rot

Violet root rot (*Helicobasidium purpureum* Pat.) sometimes causes serious damage to seakale crowns. The same precautions should be taken as recommended with asparagus (p. 47). All plants affected in the slightest degree should be burned. It is well to remember that the disease may spread from other susceptible vegetables.

WATERCRESS*

Crook Root

Crook root (*Spongospora subterranea* Wallr. Lagerh. f.sp. *nasturtii* Tomlinson) is so called because the roots of the affected plants are swollen, kinked and frequently curved in the shape of a crook. The affected roots remain stunted, become watersoaked and brownish, and ultimately decay. Plants are stunted and their leaves may become yellowish or bluish. The symptoms are due to infection of the roots with the fungus. When attacked severely the plant may lose its roothold on the floor of the bed and float away.

From October to April the crop in an affected bed gradually declines. The plants near the water outlet suffer first and the effects of the disease become progressively more noticeable from the bottom to the top of the bed until, finally, only a few yards of healthy plants remain around the water inlet.

The green variety of watercress is less severely affected by the disease than the brown variety.

Control

Some natural recovery takes place in spring and a late crop may be obtained. Anything that can be done to promote the general vigour of the plants will assist this seasonal recovery. In some beds a greater flow of water from top to bottom may be beneficial since the disease becomes worse when the water is relatively stagnant.

If, however, crook root becomes very bad during the winter so that the plants tend to lose their anchorage, the water level should be lowered so that new roots get a fresh hold on the bottom. But if this is done the beds may become more liable to damage by frost.

It has been found that zinc added to the water at 0·5 p.p.m. will control the disease. It can be applied in the form of zinc frit, a finely powdered glass containing zinc oxide, or by drip feeding a solution of zinc sulphate into the inlet water. Both methods are still the subject of experimental work, and, before trying them growers should get in touch with their local N.A.A.S. officer.

Every care should be taken to avoid infection of apparently clean beds: plants should not be brought in from other growers and the danger of carrying in particles of soil on returnable crates, boots, etc., should be realised. Diseased plants thrown on the sides of the beds are a frequent source of trouble. Infected material should be burned.

* See also Bulletin No. 136, *Watercress Cultivation*.

Cress grown from seed in sterilized soil may be expected to produce healthy plants, but cuttings may occasionally carry over crook root.

Cabbage Black Ringspot

Cabbage black ringspot (p. 11) causes a yellowish spotting or a green and yellow mottling of the leaves, especially of green cress, and reduction in vigour. It is transmissible by common aphids, and also affects cruciferous weeds, turnip, radish, and several cruciferous flowers. Clean and vigorous plants may be obtained by starting a new stock of green cress from seed, since the disease is not seed-borne.

To avoid propagating undesirable early-flowering types they should be rogued out, so that, at the time of flowering, seed is collected from the late-flowering plants only.

SALSIFY AND SCORZONERA

White Blister

The leaves of salsify and scorzonera are often attacked by white blister, caused by the fungus *Cystopus cubicus* (Strauss ex Unger) Lév., but not severely enough to warrant control measures.

CARROT

Sclerotinia Rot

Sclerotinia rot* (*Sclerotinia sclerotiorum* (Lib.) de Bary) may cause extensive rotting of carrots in storage. Roots are generally attacked near the crown by direct infection from the soil. Under close storage conditions masses of the carrots may become covered with the white threads of the fungus and its black resting bodies.

Badly damaged carrots and any roots showing indications of disease should not be stored, and all infected material should be burned. Good ventilation of the store or clamp will discourage the development of the fungus. Since the fungus also commonly attacks parsnip, beet, lettuce and dwarf and runner beans, these should not follow a diseased carrot crop.

Violet Root Rot

Violet root rot (*Helicobasidium purpureum* Pat.) is described under beet (p. 23) and asparagus (p. 47). Affected roots should be burned and other root crops should not be grown immediately following the carrots.

Soft Rot

Soft rot (*Pectobacterium carotovorum* (L. R. Jones) Waldee and other bacteria) is described under turnip and swede (p. 15). The trouble is most prevalent in highly-manured gardens. Improved drainage, destruction of diseased plants, rotation with non-susceptible crops and applications of potash, where required, are recommended.

* See Advisory Leaflet No. 265.

Alternaria Blight

Alternaria blight (*Alternaria porri* (Ell.) Ciferri f.sp *dauci* (Kühn) Neerg.) causes premature dying off of the outer leaves and petioles with occasional reduction of crop, but it is uncommon.

Black Rot

Black rot (*Stemphylium radicinum* (Meier, Drechsl. & Eddy) Neerg.) affecting stored carrots has been found in this country on several occasions in recent years. It gives rise to large sunken black lesions especially at the crown of the root. The fungus is carried on the seeds. Warm water treatment of seeds at 122° for 25 min has been found to eliminate the fungus (see Celery, p. 43). If roots showing black rot lesions are thrown on the compost heap the fungus will inevitably be returned to the soil, and it is important that they should be burned.

Downy Mildew

Downy mildew (*Plasmopara nivea* (Ung.) Shroet.) occasionally causes defoliation of carrots.

Storage Rot

Storage rot (*Centrospora acerina* (Hartig) Newhall) has been found on carrots in Scotland.

Splitting

Carrots tend to split when a dry summer is followed by a wet autumn, and this is much accentuated by nitrogenous fertilizers.

Clayburn

The name clayburn has been given to a defect of carrots found in Lincolnshire and Norfolk in places where a wet clayey soil is mixed with the normal loam. Superficial scurfy areas on the roots become bluish-black after washing. The trouble is seasonal and may be due to local asphyxiation of the tissues or to the action of poisonous salts in the clay.

PARSNIP

Canker

Canker is the most troublesome and widespread disease of the parsnip, and is sometimes responsible for serious losses. The trouble may originate in various ways. In certain varieties and in some soils a natural transverse cracking of the crown of the root takes place. This is often invaded secondarily by fungi and other organisms, which cause the top of the root to become black and rotten. The varieties that do not crack readily are apparently well-shaped, gradually tapering sorts, such as 'Large Guernsey' and 'Tender and True'. The broad-shouldered sorts with short stubby roots are most liable to cracking.

Cracking and subsequent canker is said to be worst when wet weather follows a dry period in early autumn and on highly nitrogenous or lime-deficient soils. It is prevented by methods of cultivation tending to promote regular, uninterrupted growth, and occurs less frequently in late-sown crops.

In some parts of the country, canker is due primarily to injury by carrot fly* larvae, the small tunnels of which may be seen penetrating the tissues. The injured areas are often invaded by secondary rotting organisms.

Recent work has shown that the fungus *Itersonilia* sp. first isolated from parsnips in the U.S.A. is very common on cankered parsnips in England, and is pathogenic, causing purplish brown to black, often orange flecked lesions. Very similar lesions can be caused by a *Phoma* sp.

Another type of canker, in which there are large irregular gall-like swellings, is due to the eelworm *Ditylenchus dipsaci*, which also causes "bloat" of onions.†

Control

To avoid canker, parsnips should be grown on a deep well-worked loam and manured with a balanced fertilizer. Excess of dung should be avoided. Liming should not be neglected, if it is seen to be required. Well-shaped varieties should be grown and, if possible, late sowing should be adopted. Parsnips should not be grown for two years in succession on the same ground. Attacks of carrot fly should be controlled.

Other Diseases

Mildew and leaf spots often occur on the leaves of parsnips but cause little damage. The fungi most concerned are *Erysiphe polygoni* DC., *Plasmopara nivea* (Ung.) Schröt, *Ramularia pastinacae* Bubak (=*Cercosporella pastinacae* Karst.), and *Phyllachora pastinacae* Rostr. *Sclerotinia sclerotiorum* (Lib.) de Bary sometimes attacks parsnips (Plate II), causing a storage rot similar to that on carrots (p. 19).

BEET

Seedling Diseases

The diseases that affect the seedlings may greatly reduce the stand necessary for subsequent singling.

In black leg, the stem below the seed leaves becomes black and finally shrivelled. The fungus most commonly associated with these symptoms is *Pleospora betae* Björling (= *Phoma betae* Frank), which, under conditions unfavourable for growth, may attack the seedlings. This fungus is found on a large percentage of beet seed clusters, invading the various coats which surround the true seeds. Some samples of beet "seeds" are more than 40 per cent infected. The fungus can attack the leaves, seed stems and finally the seed clusters again. It is also responsible for dry rot of the roots (p. 23). In the field it is the attack on the stems of the seedlings that is of greatest importance. The extent of the resulting damage depends on the environment. If weather and soil are not conducive to good growth, the seedlings may die off, whereas they may recover under more favourable conditions.

Damping-off of very young seedlings may be caused by fungi (species of *Pythium*) flourishing in moist conditions. This trouble is commonest in wet seasons and in the south-west. Patches in the field may die off completely. Another fungus, *Corticium solani* (Prill. & Delacr.) Bourd. & Galz., occasionally causes light brown marks on the lower parts of the seedling stems.

* See Advisory Leaflet No. 68.
† See Advisory Leaflet No. 440.

Stringy hypocotyl and stringy root are names given to symptoms that develop in acid soils. In conditions of severe acidity the stem bases or roots become constricted and stringy. Where the soil is less acid, the seedlings may grow satisfactorily unless growing conditions are also poor, owing to low fertility, to the adverse physical nature of the soil or to drought or low soil temperatures.

Mechanical damage may be caused by soil with a poor surface tilth, and continuous winds can injure plants on light sandy soils and on certain peaty soils.

Control

A good seedbed should be prepared by thorough cultivation so that the soil has a satisfactory surface tilth. Adequate manuring will ensure that the seedlings make rapid growth. The seed should be sown in favourable weather and not too early, for early sowings are more liable to encounter soil and weather conditions unfavourable for rapid germination and growth.

Organo-mercury or thiram seed dressings may be used, to promote a better stand and to prevent wholesale infection with *Phoma betae*. All sugar beet seed to be sown on contract for the British Sugar Beet Corporation is centrally treated with either organo-mercury dusts or an organo-mercury steep. When dual purpose seed dressings are used, seedling injury may be caused on light soils during dry and warm weather if the BHC content is more than 45 per cent.

Rotation with crops other than beets or mangolds helps to rid the soil of some of the fungi implicated in seedling rots (although in the U.S.A. a rotation with lucerne or beans is said to be harmful), while the correction of acid soils by the addition of lime often brings about a considerable improvement in stand of beet seedlings.

Strangles

The type of injury known as strangles is found in plants after they have been singled. There is a curious constriction of the root at or just above soil level. The parts of the root above and below the constriction continue to develop and finally the upper part breaks off or falls over. The trouble is the ultimate result of earlier injury to the seedlings by various factors.

Heart Rot

Heart rot is well known to growers of sugar beet. It reduces very considerably both the yield and the sugar content. The first symptoms become visible about the end of July or in August. The youngest heart leaves stop growing and dark brown dead areas appear on the inner surface of their stalks, which become very brittle and may curve outwards. Soon afterwards the heart leaves, and occasionally the older leaves, wilt, becoming dead and black. In wet weather secondary growth may take place and many small green leaves may appear, giving the plant a short green top. The tissues of the crown may also become shrunken and brown or black and the root may be discoloured internally.

Heart rot is due to deficiency of available boron in the soil. It is found mainly in dry seasons on light alkaline soils or on light soils that have been heavily limed. It is rare on neutral or acid soils. It is accentuated by early sowing and heavy applications of nitrogen. Affected plants may occur in patches or scattered throughout the fields.

Heart rot in garden beet develops as in sugar beet, hard black spots also appear inside the root between the rings, and cankers develop on the surface.

Control

Heart rot can be prevented by applying borax to the soil at the rate of 20 lb per acre, shortly before sowing the seed. The most satisfactory method appears to be to mix the borax thoroughly with sand, dry soil or steamed bone flour to make about 1 cwt in all. This mixture should be broadcast evenly and worked into the surface soil during the early stages of seedbed preparation, at least a week before sowing. Alternatively, the borax can be mixed with superphosphate or basic slag or with a complete fertilizer mixture. In the last case, however, it should be incorporated with the potash and superphosphate before sulphate of ammonia is added, otherwise ammonia may be set free. In severe cases, as much as 40 lb borax per acre may be required to bring about commercial control, but potatoes following the beets may be slightly injured by this amount.

Proprietary mixtures containing borax can be obtained, but if they are used, care should be taken to ensure that the amount of borax applied with the mixture does not exceed 40 lb per acre, or damage may be caused.

If heart rot has already appeared on the plants, its further development may often be prevented by applying the borax mixture as a top dressing. Lime should not be added to land where the disease has appeared or is likely to appear. Where there is any doubt, samples of the soil should be tested for lime requirement.

Violet Root Rot

Violet root rot* (*Helicobasidium purpureum* Pat.) is found on many kinds of root vegetables and on asparagus (p. 47). It is widely distributed on sugar beet, and occurs also on garden beet and mangolds. Patches of infected plants are found in the fields, probably where previous crops such as clover, lucerne, potatoes, etc., have been attacked. Little in the way of symptoms can be seen on the parts of the plant above ground, apart from slight yellowing and stunting, but when the roots are lifted, a felt-like mass of violet or purple mycelium is found, covering especially the lower parts. Such roots often bring up a mass of attached soil.

Affected roots should be discarded. If they are put in the clamp, spread of violet root rot may be unrestrained, especially if the clamp is covered with soil.

Dry Rot

The dry rot fungus, *Pleospora betae* Björling (= *Phoma betae* Frank), can cause a decay of the crowns and often invades plants affected with heart rot. The diseased areas have a shiny black appearance with decayed reddish brown or black flesh underneath, but the fungus does not usually penetrate very deeply. The surface is covered with minute, black fruiting bodies (pycnidia) of the fungus. Destruction of affected roots, rotation of crops and seed treatment with organo-mercury dusts are suggested as suitable control measures.

Scab

There are two sorts of scab organisms which affect beet. *Streptomyces scabies* (Thaxt.) Waksman & Henrici causes a pitted scab, and *S. tumuli* Millard &

* See Advisory Leaflet No. 346.

Beeley causes a knob-like scab on the roots of beets grown on the types of alkaline soils favourable to the development of scab on potatoes. Such soils should be avoided, but where their use for beet is unavoidable, ploughing-in of a green crop on farm land, or digging in grass mowings in gardens, before sowing, is recommended.

Downy Mildew

Beet plants attacked by downy mildew (*Peronospora schachtii* Fuck.) have abnormally thickened pale green heart leaves, with curled edges, ultimately becoming necrotic, brown or black, on the under surfaces of which a thick grey mat of spores is produced during moist and mild weather. Plants kept for seed are often affected, the fungus penetrating into the root and attacking the stems, flowers and seed clusters. Such plants may be very stunted and form few seed clusters. The disease is undoubtedly seed-borne occasionally, but most infection of plants grown for roots appears to come from neighbouring seed plants or old roots left in the soil.

Control

Seed from healthy crops only should be sown. Seedbeds should be well removed from plants grown for seed. Affected plants should be rogued out from the young plants destined for seed crops and from the fields, and should be destroyed. Early applications of Bordeaux mixture have been used successfully in controlling this disease.

Rust

Rust (*Uromyces betae* (Pers.) Lév.) appears on the under surfaces of the leaves. Three spore stages are found on the plant, but the orange-brown summer (uredospore) stage is especially common. As with downy mildew, plants destined for seed are most severely infected and the disease may spread from these plants to neighbouring crops early in the season. Rust is most likely to spread during autumn when there are heavy dews. Excess of nitrogen and deficiency of potassium are said to make the plants more susceptible. The disease is not usually of any great importance. It has also been noticed on spinach beet and wild beet.

Control

Beet should be located at a distance from crops kept for seed. Infected debris should be burned or ploughed under deeply. It is said that by removing and burning the first affected leaves on plants for seed the disease can be kept in check on the seed crop.

Silvering Disease

The bacterial disease known as silvering disease (*Corynebacterium betae* Keyworth, Howell & Dowson) is found mainly on 'Cheltenham Green Top', on plants grown for seed, although a few stecklings may be affected in autumn. Symptoms usually appear in April to May, when a few leaves on the flower stem or branches turn silvery grey; subsequently all the leaves become silvered and the plant wilts and dies. Much loss may be experienced.

The disease is seed borne, with considerable spread later. It can be controlled by soaking the seeds for 24 hours in a solution containing 200 p.p.m. streptomycin. Mercurial dust seed dressings are also fairly effective.

Mosaic

The symptoms of mosaic are rather variable. Generally, there is a dark and light green mottling of the leaf, sometimes taking the form of small light green spots or larger islands on a darker green background, or sometimes the converse. There is usually a distinct clearing of the veins, and the leaves may be distorted. The disease is caused by a virus which is transmitted from plant to plant by aphids or greenflies, chiefly by *Myzus persicae* and to a lesser extent in England by *Aphis fabae*. It is not seed-transmitted. It affects garden beet, sugar beet, mangold, spinach beet (perpetual spinach), and spinach, as well as the common weed white goosefoot (*Chenopodium album*) and possibly other weeds. It is common on beet plants kept for seed, but usually has little harmful effect beyond reducing the sugar content and yield of seed to some extent.

Control

Weeds should be kept down, especially those of the goosefoot family. The root crop should be well separated from plants grown for seed and from biennial plants, such as seakale beet and spinach beet, likely to carry the virus.

Virus Yellows

Practically every summer, virus yellows* is common in sugar beet and mangold fields. In mid-season a yellowing of the leaves appears on patches of plants or scattered throughout the fields. The leaves become yellowish green and finally yellow, orange or even red, in irregular areas, starting at any point, but often from the tip or edge of the leaf. These coloured areas appear waxy or become thick and brittle, so that when they are crushed in the hand they crackle and break. Under conditions unfavourable for growth, such as dull and cold weather, the coloured areas wither quickly and become invaded by weakly parasitic fungi and the symptoms may thus resemble those of potassium or magnesium deficiency. Sometimes the heart leaves may appear normal.

In sugar beet, a severe attack may result in very considerable loss of weight in the crop, accompanied by reduced sugar content if early infection takes place.

The disease is transmitted from plant to plant by the common black aphid, *Aphis fabae*, occurring on beets and to a greater extent by the more restless and omnivorous *Myzus persicae*. Plants grown for seed often carry the virus over to the second year, and bring about wholesale infection of neighbouring fields grown for roots. The disease may also attack other wild and cultivated plants of the beet family, such as spinach, spinach beet, seakale beet, etc., and occasionally weeds of other families, such as chickweed and groundsel.

Control

The young plants or stecklings destined for seed production should be raised from seed (usually sown in July) in a district remote from any beet root crops. Little harm will then result from planting these out near to beet root fields in the late autumn or early spring. In view of other diseases carried over the winter on seed crops, however, it is advisable to maintain as great a distance as possible between seed and root crops. Regulations now restrict

* See Advisory Leaflet No. 323.

infection of approved steckling beds in England to less than one per cent.

Mangold clamps, which are the main overwintering sources of virus yellows and viruliferous *Myzus persicae*, should be placed as far away as possible from next year's sugar beet, beet, and mangold fields, and should be cleared as soon as the roots are finished. It is also advisable to top the roots before clamping if they are intended for late feeding to stock.

Spread of virus yellows in sugar beet root crops can be reduced by spraying with systemic insecticides when green aphids begin to become common, usually about June. A second spraying two or three weeks later may be necessary.

Speckled Yellows

Speckled yellows is due to deficiency of manganese in the soil in a form available to the plant. The first symptoms begin to appear about singling time, the interveinal areas becoming yellowish green. Later these areas become brown and dead and may fall away from the leaf. Many of the affected leaves are erect and later assume a triangular shape, due to the edges rolling inwards. Manganese deficiency symptoms are very marked in globe beet, the leaves of which become abnormally red and have numerous small, pale red, irregular areas between the veins. Spinach and spinach beet may also show speckling, chlorosis or scorching.

Manganese deficiency is comparatively common on thin peaty soils overlying calcareous subsoils, for example on the so-called "skirt" soils of the Fens. But it may also occur on other types of soil in which similar conditions are induced, such as those which are naturally calcareous, especially after ploughing in grass on soils rich in humus, through which there is a seepage of water containing lime, or on market-garden soils to which heavy dressings of both poor quality stable manure and lime have been applied for a long period. The conditions common to all cases are a high content of organic matter and a high lime status.

Symptoms appear to be most severe during midsummer, and a fair amount of natural recovery may follow.

Control

Lime should not be applied in excess to soils which may have a tendency to produce speckled yellows. Since beet is liable to fail in very acid soil it is best to aim at having a state of medium acidity.

If the characteristic symptoms begin to appear, the leaves may be watered or sprayed with a solution of manganese sulphate. Excellent recovery has been achieved within a fortnight by applying this by means of a sprinkler at the dilution of 2 oz per 5 gal water, with the addition of a spreader, such as sulphonated lorol or ester salts. The long varieties of beet, e.g. 'Cheltenham Green Top', appear to be much less susceptible than the globe sorts.

Crown Gall

Crown gall (*Agrobacterium tumefaciens* (Smith & Townsend) Conn.) produces large tumours on the sides of the roots. Infected roots should always be burned, for the bacteria in question can attack many different kinds of plants.

Leaf Spot

In countries where high temperatures and high humidity prevail considerable damage is caused by leaf spot (*Cercospora beticola* Sacc.) but it is comparatively

harmless in England. The spots are numerous, round and small, greyish in the centre and surrounded by a reddish margin. The centres may fall out, giving a "shot hole" appearance. When a plant is badly attacked it produces new leaves in the crown, which become elongated. Seed beet in its second year may become attacked, and stalks, flowers and seed clusters infected. The disease is occasionally seed-borne. The fungus can also infect a number of widely different kinds of plants. Control is usually unnecessary. In other countries Bordeaux mixture or other copper compounds are employed as protectants. Rotation of crops is important.

Ramularia beticola Fautr. & Lamb, causes a very similar type of spot while *Pleospora betae* Björling, produces large leaf spots with concentric rings.

Mineral Deficiencies

In potassium deficiency the margins of the leaves are scorched and rolled inwards, while in magnesium deficiency there are pale areas followed by scorching between the veins.

RADISH

Radishes are subject to club root, white blister, downy mildew, violet root rot, sclerotinia rot, scab, and canker (*Corticium solani*) and other diseases that attack turnips and brassicas generally. These diseases, however, do not occur very frequently and the damage is seldom serious.

SPINACH

Downy Mildew

Downy mildew (*Peronospora effusa* (Grev. ex Desm.) Rabenh.) often attacks spinach and may cause serious damage. Yellow patches appear on the leaves and a grey or violet-grey mould develops on the lower surfaces. The disease spreads markedly under moist conditions and at low temperatures. Adequate drainage of the soil is essential for its control.

Spinach Blight

Spinach blight, caused by the cucumber mosaic virus* (p. 60), is common in some parts of England where spinach is grown. The first symptoms are a yellowing of the younger and later of the outer leaves. The inner leaves become much distorted and puckered, or dwarfed with inward rolling of the margins, while the outer ones become yellow and limp and lie flat on the ground. Finally the leaves rot off from the tips, and the plant may be reduced to a small central whorl of leaves or may die off altogether.

The virus is probably not seed-borne but may reach winter spinach from vegetable marrow, on which it causes a mosaic appearance (p. 63). It may also originate from wild hosts, such as white bryony (*Bryonia dioica*) in hedgerows and from wild solanums and certain ornamental plants, such as asters, delphiniums, polyanthus, etc., which are susceptible. It is carried from plant to plant by aphids, such as *Aphis gossypii* and *Myzus persicae*, and probably also on the hands of workers.

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* See Advisory Leaflet No. 340.

Control

Where winter spinach is grown, it is important to keep down mosaic in neighbouring marrow beds and to practise clean cultivation. The disease is worst in early-sown crops, as with lettuce mosaic on winter lettuces, and it can be reduced by postponing the date of sowing until the latter half of September.

Leaf Spot

Leaf spot (*Heterosporium variabile* Cooke) occasionally occurs in England. The spots are up to ¼ in. in diameter, circular, light greyish-brown and sunken, with well-defined brown or purple margins. In the centre of each spot a raised olive-green pad of fungus fructifications is produced. The spots often coalesce and involve most of the leaf, which becomes brown and withered.

The disease is believed to be favoured by badly drained soils and malnutrition of the plants. Spraying with copper fungicides has been suggested for controlling it.

Virus yellows of beet (p. 25) also affects spinach.

ONION, LEEK, ETC.

Smut

Smut* (*Urocystis cepulae* Frost) is a serious soil-borne disease of onions. It is found in England on both bulb and salad onions and has been recorded on leeks, shallots, chives and garlic.

The first young leaf of the seedling onion is attacked below or just at the surface of the ground. Once inside the plant the fungus may spread to the growing point with the result that succeeding leaves become affected. Dark lead-coloured stripes develop under the skin of the leaves and scales, and finally burst open, revealing masses of black powdery spores (Plate II).

If the seedling is not killed, the spore masses may continue to develop on the older leaves. The spores readily reach the soil, which becomes contaminated and unsafe for sowing with onions or leeks for a long period. The fungus may also penetrate to offsets.

Under the Sale of Diseased Plants Orders of 1927 to 1952, the sale for planting of any onion or leek plants which are substantially infected with smut is prohibited.

Control

It is most important to collect and burn infected seedlings and plants, while every effort should be made to prevent contaminated soil being distributed on workers' boots, tools and plants grown in the infected area.

Although it is not possible, in practice, to eradicate smut from soil, it has been found that reasonably healthy stands of onions and leeks may be raised in contaminated soil by watering the seed drills with diluted formalin. The method consists in allowing diluted formalin to trickle into the soil in the drill immediately after the seed has been sown, and before it has been covered with soil. This can be done on a small scale with an ordinary watering can, without a rose. For larger sowings, however, it is convenient to attach to the seed-drill a small metal tank holding from 2–5 gal and having an outlet

* See Advisory Leaflet No. 261.

leading down to the drill, behind the seed spout. The outlet pipe should be provided with a tap or other contrivance so that the quantity of solution delivered behind the seed as the machine is pushed along shall be adequate, but not excessive. Preliminary trials with water on land adjoining the plot to be sown will assist in enabling the flow to be gauged so that the right quantity may be distributed over a given length of drill.

The solution normally required is made by adding 1 pt formalin (40 per cent) to 16 gal water, and this amount will suffice for about 800 yards of drill. The drill is closed immediately after the formalin has been applied. Unless the soil is exceptionally dry there is practically no risk of injury to the germinating seed by this treatment, and sowing more thickly than usual is neither necessary nor desirable. Experience in this country has tended to show that this formalin treatment is advantageous, quite apart from its control of smut, for germination is accelerated and the young plants grow ahead more rapidly when it is applied. If the soil is unduly wet, the formalin becomes further diluted and may sometimes fail to protect the seedlings sufficiently from smut attack. Rain at sowing time, or soon after, diminishes the good effect of the formalin. Where such conditions exist or are likely to prevail, the strength of the solution may be increased to a maximum of 2 pt formalin (40 per cent) to 16 gal water, this quantity of solution being applied along 800 yards of drill. It should clearly be understood that the treatment by no means exterminates the smut fungus from the soil, and it must be repeated with each successive sowing.

The "pelleting" method of seed treatment against onion smut, which is being widely used in America, has given good results here where soil contamination is not excessive. A large amount of fungicidal dust is made to adhere to the seeds by means of a sticker.

Methyl cellulose ($4\frac{1}{2}$ g in 90 c.c. lukewarm water) is stirred thoroughly with every pound of seed, one pound of 50 per cent thiram (tetramethylthiuramdisulphide) or ferbam (ferricdimethyldithiocarbamate) added, and the whole shaken vigorously for 5 minutes. In the U.S.A. captan is also said to be effective.

Alternatively, a resin sticker may be used, composed of 27 per cent of resin dissolved in industrial methylated spirits, sp.gr. 0·825; 22 c.c. are shaken or stirred with every pound of seed, a pound of the fungicide added, and the whole shaken vigorously. The seed should be spread out in a thin layer and dried completely before being put in a bag. The resin-alcohol sticker is cheap, easily prepared, and dries quickly.

This method is more effective than the formaldehyde drip method in districts with a heavy rainfall at sowing time. It does not require any special adaptation of the seed drill, but the aperture should be increased slightly.

Downy Mildew

Onions are attacked most severely by downy mildew* (*Peronospora destructor* (Berk.) Casp.) in wet parts of the country and in areas which are low lying and badly drained, where it may cause much loss in cool, wet seasons. The leaves die from the tips downwards and become covered with a fine downy growth of fungus filaments, at first grey and finally brownish-purple. Secondary black moulds may then develop on the dying leaves. The downy

* See Advisory Leaflet No. 85.

mildew spores become distributed from plant to plant, and in wet weather epidemics of the mildew occur. As a result, the tops of the plants may die entirely and the bulbs may fail to mature.

The fungus also progresses down the leaf-bases into the bulb. The disease may therefore be carried over from season to season in infected sets, potato onions, shallots, onions grown for seed, Egyptian or "tree" onions and perhaps other species of *Allium*. It may also be carried over in the soil, which becomes contaminated with the resting spores of the fungus; and possibly occasionally in or on the onion seeds.

Control

Control of the disease is often very difficult because of the conditions prevailing where it is most likely to occur. Open, well drained situations, preferably with light soil, should be selected for the crop, and weeds should be kept down, to avoid a stagnant atmosphere round the plants.

Onions should never be sown on soil that has recently carried a diseased crop. Autumn-sown onions should be grown as far away as possible from a mildewed summer crop and the later they are sown the less risk there will be of infection. Similarly, spring-sown onions should be located at some distance from autumn-sown plants. Where the disease has been troublesome, raising seedlings under glass from December to January, and subsequently transplanting, is preferable to autumn sowing in the open. Where sets are planted, only those that are firm and sound and not prematurely sprouted should be used.

Prompt removal of affected plants will help to prevent much of the crop from becoming infected. Debris from diseased plants should be collected and burned and never incorporated in the soil or in compost heaps.

Spraying with Bordeaux mixture has been recommended, but has not given very satisfactory results. Only applications made before the fungus has actually appeared are likely to give any control. Downy mildew is said to be controlled in Australia by spraying with zineb (1½ to 2 lb per 100 gal), plus a good spreader (4–6 fl. oz) every fortnight, commencing at the first appearance of the disease.

Varieties of onions differ considerably in resistance to the disease. 'Cranston's Excelsior' is highly resistant in the foliage, but the bulbs are very susceptible. 'Up-to-date' is highly resistant in foliage and bulbs. 'Ailsa Craig' is less resistant, while 'Bedfordshire Champion' and 'James's Keeping' are highly susceptible, although the former is somewhat resistant in the bulbs. Bunching onions ('White Lisbon') do not become affected.

White Rot

Onions and leeks are both affected by white rot* (*Sclerotium cepivorum* Berk.) although leeks are less commonly attacked. The leaves become yellow and die back, and when the plants are pulled up the roots are found to be rotten and the base of the bulb covered with a white or grey fungus growth. Later, numerous small black spherical bodies are produced, the sclerotia or resting bodies of the fungus, while the bulb of the onion may become completely rotten. In this country the disease is worst in warm summers, or, in the case of winter onions, during warm spells in autumn or spring.

* See Advisory Leaflet No. 62.

Control

The causative fungus is soil-borne and its resting bodies can remain in the soil for at least eight years in the absence of a susceptible crop. It is advisable therefore to give the ground as long a rest from such crops as possible. Infected onions should be dug up with some of the surrounding soil and burned; they should on no account be left in the soil or incorporated in the compost heap. There is some indication that heavy manuring with organic manures reduces disease in the crop.

With spring sowings some control can be obtained by applying a 4 per cent calomel dust to the seed drill at the time of sowing at the rate of about 1 lb per 25 yd of drill. Half that amount may suffice if the onions are to be pulled early for salad purposes. For large acreages the dust may be broadcast at the rate 1 oz per sq. yd and raked in before sowing.

The bases of shallots or transplanted onions may be dipped in a calomel paste consisting of 3 lb to 1 pint of water. One pound is sufficient for 150 shallots or 200 onion seedlings; 3 oz of the dust mixed with each bushel of seed compost is stated to prevent the development of white rot in seed boxes.

The seed pelleting process recommended against smut has also been used successfully against white rot. In this case calomel (mercurous chloride) is employed. For salad onions ½ to ⅔ lb of pure calomel should be pelleted (see under smut) per 1 lb of seed and for bulb onions 1 lb calomel per 1 lb seed. With pelleted seed of bulb onions especially it is desirable to open up the seed drill slightly in order to give the usual rate of drilling.

A claim is also made that quintozene (pentachloronitrobenzene) at the rate of 2 oz of a 20 per cent dust per sq. yd, raked into the soil four or five days before seed sowing, will check development of white rot.

Although no varieties of onions are immune, some are more resistant to this disease than others. The bunching onion 'White Lisbon' is particularly susceptible.

Shallot Virus Yellows

Shallots are frequently affected by virus yellows and similar symptoms are occasionally seen on onions. In plants growing from infected bulbs the first signs of infection are short yellow streaks on the first leaf emerging from the bulb. Subsequent leaves show severe streaking or become yellow throughout. They are also irregularly crinkled and somewhat flat, tend to fall over, and the plant is dwarfed.

The virus is carried from plant to plant by several kinds of aphids or greenflies, so that onions grown from seed, which is naturally healthy, may become infected from nearby shallots or other onions grown from sets.

This disease closely resembles yellow dwarf, a virus disease found on onions in America.

Control

Diseased shallots or onions, if they are not too numerous, should be removed as soon as the symptoms become clear. Onion seed should not be sown close to plants derived from sets.

The Department of Agriculture for Scotland operates a certification scheme for shallots, and their certificates cover freedom from virus diseases.

White Tip

White tip (*Phytophthora porri* Foister) of leeks was first recorded from the Edinburgh leek-growing district in 1928, and has since been found in several parts of the country. The tips of the leaves take on a waterlogged appearance and finally die back, becoming white and papery as if bleached by frost. Similar areas may occur at the margins, centres or bases of the leaves. Affected basal leaves usually rot off and the growth of the plant is greatly checked. Even when slightly attacked, the plants have an unsightly appearance and wilt quickly after being gathered, whereas healthy plants remain fresh for many days.

In this country the disease usually begins to appear in the leek fields in August or early September, and becomes general from October onwards. At first only a few plants are attacked and from these the disease spreads outwards in a circle, most infection taking place during wet weather.

Control

All refuse from diseased plants should be collected and burned, because it has been demonstrated that such refuse, left in the soil or incorporated in compost heaps, will carry over the disease to the following season, no doubt owing to persistence of resting spores of the fungus. As long rotations as possible should be practised. Sometimes the ground has remained infective for as long as three years after carrying a diseased crop.

As soon as the disease appears, affected plants should be pulled out to prevent further spread. Trials have shown that if infection has not gone too far the disease may be kept in check satisfactorily by spraying the plants with Bordeaux mixture or similar copper compounds, or dusting with copper lime dust at intervals of a fortnight to three weeks. It is important to apply these treatments early. There is evidence that some strains of leeks are more resistant to the disease than others.

Shanking

Yellowing and shrivelling of the leaves of onions and shallots, accompanied by softening of the bulb and shrivelling of the roots, may be caused by species of *Phytophthora*. Some of these fungi produce the similar trouble known as shanking of tulips, and foot rot of tomatoes. Others appear to be related, respectively, to the fungi which cause the white tip disease of leeks and the pink rot disease of potato tubers.

Soil used for raising onions under glass should be sterilized. In the field it may be dangerous to plant onions after leeks, potatoes, or a previous onion crop.

Rust

Elongated bright orange spots are often found on the leaves of leeks, especially during rather warm weather (Plate VIII). They are caused by a rust fungus (*Puccinia porri* (Sow.) Wint.), attacks of which are sometimes sufficiently severe to kill off the lower leaves and check the growth of the plant considerably. The rust is also found on chives and garlic. With the onset of cooler weather in late winter the plants usually grow out of the disease, the newly produced young leaves being unaffected. The disease appears to be worse on soils rich in nitrogen but deficient in potassium. It is sometimes carried over

from one growing season to another on discarded plants in the headlands. All refuse from affected crops should therefore be destroyed.

Leaf Rot

In the western counties, winter onions, such as the 'White Lisbon' bunching onion, are affected during the wet months in winter by a tip rot associated with the fungi *Botrytis cinerea* Fr. and *B. squamosa* J. C. Walker. Small cricular or elliptical white spots, often surrounded by water-soaked margins, appear near the tips of the leaves. The areas surrounding the spots eventually dry out and become yellowish-green or grey and the leaf-tips shrivel up and collapse. During wet weather these become covered with the grey fur-like fructifications of the fungus. The younger leaves are less affected than the old ones. The variety 'Chandawil Bright' is very susceptible.

The disease may cause loss both by checking the growth of the plants, and by making them unsightly and consequently of poor market value. Slightly affected plants often outgrow the disease when growth begins again in spring. The trouble is most severe on highly nitrogenous soils and may then often be checked by manuring with potash. Leaf rot is said to be controlled in the U.S.A. by spraying with zineb or captan (see Downy Mildew, p. 29). Thinner sowings, under 35 lb of seed per acre, have been found to be much less affected than thicker sowings of 50 lb per acre.

Neck Rot and Bulb Rot

Severe loss to onion and shallot bulbs in storage may be caused by neck rot and bulb rot (*Botrytis allii* Munn and *B. byssoidea* Walker). The causative fungi enter the bulbs at the neck or base, or through wounds or splitting at the side, and induce a soft, brownish rot of the scales, giving them a cooked appearance. *B. allii*, which is by far the commoner fungus, produces a dense greyish felt consisting mainly of spores, and, later, small black rounded sclerotia or resting bodies. *B. byssoidea* produces a white woolly mycelium, followed by kernel-like black sclerotia.

Control

Not more than two crops should be grown in succession on the same ground. Manuring should be balanced, avoiding excessive nitrogen. Late hoeing may injure the bulbs and lead to rots.

Proper harvesting and storage methods are of the very greatest importance. It is often the practice to lay the foliage by hand. This is done, towards the end of August or September when the plants have reached their maximum growth, by bending the leaves of two rows towards one another. When the onions are ripe, i.e., when the tops tend to fall over naturally and the bulbs are firm, with thin, dead and wiry roots, they should be pulled up and laid on their sides in rows on the ground, with the roots exposed to the sun. In wet weather it may be necessary to turn them over several times. After two or three weeks, when the necks are thoroughly dry and skins crisp, the excess of withered leaves at the tip should be twisted off. Immature, split, thick-necked and diseased specimens should then be separated from the onions which are to be stored.

The chief storage requirements are abundant ventilation and protection from rain and excessive damp; frost is not usually harmful. Small quantities may be made into ropes and hung in a well-ventilated shed or placed in trays

with a bottom of slats or wire netting. The following Dutch method is often employed. Structures are built of hurdles and slats or wire netting. They may be trough-shaped, wider at the top than at the bottom, well raised off the ground, with slatted floors and sides and an overhanging roof of thatch or other weatherproof material. The onions are placed in a layer not more than three feet deep. Old chicken houses provided with extra ventilation near the ground and from which some of the floor boards have been removed have also given good results.

In Bedfordshire, onion lofts are a characteristic feature of the landscape. These are high narrow sheds with a low-pitched roof. Below the eaves there is generally a strip of ventilators, and doors on each side of the loft make for easy access to the slatted shelves or floors, usually six in number, arranged one above the other.

Roots and dry foliage should be removed before marketing, care being taken to keep out all diseased and decayed onions.

Fusarium Foot Rot

Fusarium foot rot (*Fusarium culmorum* (W. G. Sm.) Sacc.) attacks leeks causing the leaf-sheaths to rot at soil level. The whole of the stem and leaves may collapse or the leaves may wilt successively from the outside of the plant inwards. A characteristic feature is the reddish or pink coloration of affected parts.

The disease is contracted from the soil and is most active during warm and moist weather. It becomes troublesome only when leeks are grown on the same soil year after year. Care should be taken, therefore, to remove and burn diseased plants and to grow the crop on fresh soil as often as possible.

Soft Rot

Soft rot (*Pectobacterium carotovorum* (L. R. Jones) Waldee and other bacteria) is often found on stored onions and has been reported on leeks. The plants become glassy or water-soaked and finally disintegrate into a soft watery mass. Infection usually begins at the neck, often while the plants are still in the ground. Losses may be avoided by crop rotation and by attention to harvesting, curing and storing. Soft rot of the bulbs often follows shanking (see p. 32).

Bacterial Spot

Bacterial spot (*Pseudomonas* sp.) affects the seed-stalks of leeks.

Smudge

Smudge (*Colletotrichum circinans* Berk.) Vogl.) occurs on onions, shallots and leeks as black smudges on the outer scales. This and other fungi are liable to discolour onions considerably if the plants become wet during harvesting and are not dried sufficiently before storage.

Damping-off of Seedlings

Some control against damping-off of seedlings (*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.) can be got by pelleting the seeds with calomel as used against white rot.

LETTUCE

Grey Mould

Grey mould (*Botrytis cinerea* Fr.) is very destructive to lettuce in the open ground, in frames and in glasshouses.

In the Field or Garden

During late winter and early spring, when winter lettuce in the open are making little growth, there may be some withering of the older leaves following frost or wet weather, especially in badly drained situations. These leaves are readily attacked by *Botrytis*, which works its way into the stem and brings about a reddish discoloration. Subsequently, the stem may rot entirely and break off near the surface of the ground. The ashen-grey fructifications of the fungus are produced in abundance on the decaying leaves (Plate III) and the disease spreads rapidly from plant to plant. Small black resting bodies or sclerotia are formed which may remain in the soil and lead to infection of later lettuce crops.

Botrytis also attacks the tips of the leaves, causing a marginal rot which may develop finally into a slimy soft rot of the whole lettuce. This type of soft rot is most common on summer lettuce during periods of moist weather. There is no doubt that *Botrytis* may be the primary cause of marginal scorching, but sometimes it is merely a secondary invader. Marginal scorching may be initiated by mosaic disease, by deficiencies of certain elements such as potassium, and possibly by bacteria. There is also a scorching of physiological origin familiar to most lettuce growers as "greasiness", possibly identical with what is called "tip-burn" in the U.S.A. This is associated with periods of hot weather and vigorous growth, or with high concentrations in the soil of salts, especially ammonium and potassium sulphates, in dry seasons.

Control

Well-drained situations are essential and it has been observed that most loss occurs in hollows and in fields and areas subject to temporary waterlogging. If losses recur from year to year soil or plants should be submitted for analysis, to find out whether there is a lack of balance between essential elements. It is also possible that very light soils may be unsuitable. When the seedlings are planted it is important that they should not be placed too deep; their crowns should be raised slightly above the soil.

There is a considerable difference in the susceptibility of different winter varieties, those that are most winter-hardy being least susceptible. The most resistant of the winter cabbage lettuce are 'Arctic', 'Arctic King' and 'Imperial'. Of the older types 'Stanstead Park', a slightly tinted variety, is highly resistant.

Where persistent losses are experienced, good results have been obtained by the use of proprietary dusts containing chloronitrobenzenes (p. 92). Twenty per cent quintozene may be applied to the seedbed by means of a blower after sowing, while five per cent tecnazene may be applied to the bases of the plants in the seedbed and before transplanting. If the disease appears, further dustings may be given to the plants in the field. In the case of spring plantings a single dusting of the seedbed before transplanting has given good results.

In the eastern counties and elsewhere it is customary to sow hardy varieties in cold frames or cloches from October to November and to transplant the seedlings into the open ground early in the year. A single dusting, before transplanting, as described above, appears to be particularly advantageous. Affected seedlings can be recognized by their red bases, a condition known as "red leg" in the Thames Valley, and are best discarded and destroyed. Control of *Botrytis* in frames is described below.

LETTUCE IN FRAMES

Botrytis

The use of suitable varieties and careful attention to cultural details* will usually minimize the risk of loss from *Botrytis*. For the early spring crop, varieties such as 'May Queen' (syn. 'May King', 'May Princess' and 'Northern Queen' are suitable.

The *Botrytis* fungus may be carried over in the seed and is liable to infect the seed-leaves when they begin to decay. It is advisable, therefore, when pricking out, to discard any seedlings with damaged or diseased seed-leaves. Frames containing seedlings should be ventilated for half an hour or so by lifting the light at the lower (front) edge only, during spells of warm and dry weather. This should also be done after frost, to allow the plants to thaw slowly. The frames to which the lettuces are finally transplanted usually need little ventilation. The frames should be moved at least once in two years or entirely fresh soil introduced. Alternatively the soil can be sterilized by means of formalin (p. 84). After planting out, any young plants showing evidence of *Botrytis* infection should be removed as soon as possible.

Where losses from *Botrytis* are persistent, they can be reduced by the use of proprietary dusts containing chloronitrobenzenes. A 20 per cent quintozene dust may be applied to the seed bed before sowing at the rate of 1 oz per sq. yd. Light dustings of 5 per cent tecnazene may then be applied to the seedlings at fortnightly intervals. Alternatively, thiram may be used at 0.2–0.4 per cent of the active material in water. A 4 per cent chloronitroaniline dust can also be used, raked into the surface of the soil before planting out in the frames.

LETTUCE IN GLASSHOUSES

It should be emphasized that *Botrytis* is unlikely to be a problem on glasshouse lettuce, where growing conditions and crop management are good, and the houses are suitable for the purpose. The houses should be thoroughly cleansed before cropping, preferably with a formaldehyde solution (see cleansing of houses, p. 95). The popular cold house varieties, 'May Queen', and 'May Princess', especially the former, are quite resistant to *Botrytis* when well managed and grown cool. The varieties usually grown under heated glass, 'Cheshunt Early Giant' and 'Cheshunt 58', also do not succumb to the disease if well grown†.

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* For cultural information, see Bulletin No. 55, *Outdoor Salad Crops*.

† For cultural information, see Bulletin No. 143, *Salad and other Food Crops in Glasshouses*.

Grey mould is encouraged by poor temperature control and inadequate ventilation. Plants that are limp and floppy, and checked in growth, through receiving insufficient water are very often the starting point of trouble; and adequate watering from the outset is all important for vigorous growth and avoidance of this disease. Old and withering or damaged leaves, particularly those in contact with the soil, are trouble spots in poorly managed crops.

At planting time the soil surface should be level, free from stones, and with not too fine a tilth. If organic manure is to be incorporated, it should be dug in thoroughly at an early stage of soil preparation, so that none is exposed on the surface after planting. Serious losses from *Botrytis* are likely to follow any attempt to work organic matter (such as short manure or spent mushroom compost) into the surface just before planting. Every exposed scrap of manure is a breeding ground for *Botrytis*.

Deep planting should be avoided, and the plants should be set out with the neck of the seedling slightly above the soil surface.

If grey mould succeeds in developing in glasshouses, it is usually difficult to contend with, and strict attention to hygiene and other control measures are necessary if losses are to be kept down. Where the grower is frequently unsuccessful in producing *Botrytis*-free crops, the use of proprietary dusts containing chloronitrobenzenes can be helpful. Treatment results in some check to growth, which delays hearting by 10 days or more, and unless the losses are otherwise considerable, the cost and reduced returns from treatment may offset the gains from a clean crop.

In cold houses, a 20 per cent commercial formulation of quintozene can be applied at 1 oz per sq. yd, and worked thoroughly into the top 3 in. of soil. This should be done 2–3 weeks before sowing, or 2-3 days before planting out.

In heated houses proprietary dusts containing 5 per cent tecnazene can be dusted on the soil before planting out, and subsequently, as a cloud treatment, if the disease appears. Tecnazene can also be applied from a smoke generator.

A chloronitroaniline formulated as a 4 per cent dust is also used in the control of *Botrytis* disease of lettuce. It is applied to the soil before planting out, at the rate of ½ to 1 oz per sq. yd and lightly raked in. On glasshouse crops, the soil treatment is considered to be sufficient to afford good control if the lettuce is cut within twelve weeks. Crops grown for a longer period require an additional dusting treatment of ¼ oz per sq. yd. A minimum period of three weeks is officially recommended between the last treatment and harvesting to avoid residues.

Where the seeds are sown in unsterilized soil or pricked into soil blocks such soil can be similarly treated by mixing the chemical with the surface layer.

A dust formulation of the antibiotic griseofulvin has recently been tried against *Botrytis* on lettuces in heated or unheated glasshouses. It is applied at 1 oz per 20 sq. yd when the first true leaf appears, and again about 14 days later, after pricking out. Subsequently applications at 14 lb per acre are made within 14 days after planting and at four-weekly intervals afterwards. The final application should be made at least four weeks before cutting.

Sclerotinia Disease

Sclerotinia disease (*Sclerotinia sclerotiorum* (Lib.) de Bary) is common on lettuce in this country only in the warmer districts during the summer. The

fungus attacks the plants at ground level, causing the leaves to collapse suddenly. Affected plants ultimately become soft and watery and are permeated by the copious white fluffy mycelium of the fungus, which later develops large black sclerotia or resting bodies. These can live in the soil until the following season and ultimately give rise to very small, flat, toadstool-like bodies which release spores that may infect other plants.

The same fungus is able to attack certain weeds and ornamental plants, especially those with semi-woody hollow stems, and it has also been found in this country on potato, carrot, turnip, parsnip, beet, dwarf beans, etc.

Control

Prompt removal of affected lettuces with a little of the surrounding soil will prevent sclerotia from being formed in the soil and infecting later crops. This debris should be burned and not placed on the compost heap. In plantings where many lettuces are affected it may be advisable to soak, with copper sulphate (bluestone) solution (1 oz to 2 gal water), the soil from which the diseased plants have been removed. Dwarf beans, carrots, parsnips, etc., may succumb if planted after diseased lettuces. Brassicas are not usually badly affected in this country.

Ring Spot

Ring spot (*Marssonina panattoniana* (Berl.) Magn.) is sometimes called "rust" by growers. The symptoms are small circular brown spots about $\frac{1}{8}$ in. in diameter on the leaves, and sunken brown markings resembling slug injuries on the undersides of the midribs. The centres of the leaf spots may fall out, giving a shot-hole effect. Under moist conditions the pink fructifications of the fungus may develop on the edges of the brown spots.

The disease may dwarf the plants considerably if they are attacked early. Usually the spots are found only on the outer leaves, which are disfigured and have to be pulled off before the lettuces are marketed. Affected winter-hardy lettuces may be scattered here and there in the fields in early spring, and the disease often spreads from these plants in more or less circular patches. It is found occasionally, too, in leaky glasshouses.

The fungus may be carried over for a short time on the seeds, or may remain alive on debris in the soil for at least several months. There is also evidence that the fungus may affect some common weeds, such as species of sow thistle (*Sonchus*). Ring spot causes most damage after cold and wet weather and in badly-drained situations. Where lettuces are planted among plum trees, for instance, it is less serious on plants over the tree roots, where drainage is better.

Control

In the west of England the variety 'Imperial' is more susceptible than other hardy winter varieties, such as 'Arctic' and 'Arctic King', which are somewhat resistant in the open. Lettuce should be sown and planted out on well-drained situations and adequate rotations should be followed. On no account should plants be grown on ground that has recently borne a crop affected with ring spot. Plants raised under glass and put out in early spring are usually less infected than those overwintered in the open. Infected debris should be burned and not returned to the soil or the compost heap.

Spraying the young plants in the seedbeds with 1 per cent Bordeaux

mixture or similar copper compounds may give good control in winter lettuce which are not transplanted into the fields until January or February, but growth of the plants may be checked somewhat. Good results have been achieved with 0·2 per cent* captan or thiram, applied in the seedling stage and subsequently at intervals throughout the season. The undersides of the leaves should be reached by the spray.

Downy Mildew

The symptoms of downy mildew (*Bremia lactucae* Regel) may be inconspicuous on seedlings, or show as large pale green or yellow areas, usually bounded by the veins, on the lower leaves of larger plants. The white or greyish fructifications of the fungus are copiously produced, usually on the lower surfaces of the leaves. Later, and especially under wet conditions, the diseased patches may become secondarily invaded by soft rot bacteria and the outer leaves become brown and slimy.

The disease is most troublesome on forcing varieties during late autumn in cold houses, when the plants are growing in cold and wet soil, or when the leaves become wet from overhead watering or drips from the roof. Out of doors it may cause damage to stands of seedlings in wet weather in spring, or to summer lettuce when there is heavy dew or rain in the autumn. The fungus appears to be transmitted very occasionally in commercial seed.

Control

There are at least two strains of the downy mildew fungus in England. One of them, usually found out of doors, infects 'Cheshunt Early Ball' and 'Cheshunt Early Giant' severely, 'Golden Ball' slightly, and does not infect 'Gotte à forcer', 'Loos Tennisball', 'Early French Frame' or the 'Blackpool' strain of 'Early French Frame'. These latter varieties will not, therefore, take the disease where this strain of the fungus is involved. A second strain of the fungus, however, has also been found, usually in greenhouses, which attacks all these varieties indiscriminately. The first (specialized) strain has been found on *Lactuca serriola*, the wild prickly lettuce. Strains of the fungus on other plants of the daisy family do not infect lettuce.

The lettuce are most susceptible in the early seedling stage. Good results have been obtained by spraying both indoor and outdoor lettuce with thiram 0·4 per cent solution, just after emergence and subsequently at intervals of three weeks. Zineb is also effective, but some formulations may cause scorching.

The houses in which the plants are put out should be well watered previous to planting and, if possible, heated so as to maintain a buoyant atmosphere. If the plants develop downy mildew after being put out, the lower affected leaves should be removed and the temperature raised to 60–65°F for at least one night. The plants should not be watered again unless the ground becomes dry. In frames also the disease can usually be kept well in hand if the lower leaves are removed.

Damping-off

Damping-off (*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.) is sometimes reported on lettuce seedlings grown in boxes or frames, even when the soil is comparatively dry (Plate XI). The leaves of very young plants flag and lose their lustre, a condition referred to by some growers as "drop". In older

* 2 lb per 100 gal water.

plants the leaves touching the ground are attacked and become water-soaked with reddish veins, the symptoms somewhat resembling those of grey mould.

Where soil infestation is suspected it should be sterilized with formalin. A 20 per cent quintozene dust may be applied to the seedbed before sowing at the rate of up to 2 oz per sq. yd. If damping-off appears in the seedlings, the affected ones may be removed and the adjacent ones treated with tecnazene, or thiram or captan applied at 1 tablespoonful per gallon of water (at up to 1 pt per sq. ft), watered on the affected area after the diseased seedlings have been removed.

Bacterial Wilt

This disease (*Pseudomonas marginalis* (N. A. Brown) Stevens) resembles Botrytis rot and has been found in heated glasshouses. As the plants approach maturity they become dull dark green in colour, then wilt suddenly and collapse. The vascular bundles are blackened. The disease is usually associated with wet soil conditions.

Leaf Spots

Leaf spot (*Pleospora herbarum* (Fr.) Rabenh.) causes small, light brown, more or less circular spots to appear on the outer leaves. These enlarge, and may later coalesce to form a large affected patch which dries and shrivels. The centres of the spots may fall out, leaving dark brown margins. *Septoria lactucae* Pass. causes olive-brown leaf spots up to ½ in. long, often surrounded by yellow areas. These diseases are not usually serious enough to warrant control measures.

Lettuce Mosaic

Mosaic is prevalent wherever outdoor lettuce are grown in Britain. The trouble is due to a virus which is transmitted from plant to plant by certain kinds of aphids or greenflies, especially *Myzus persicae*.

On winter-hardy lettuce in the open ground the symptoms become strikingly apparent in early spring. Affected plants are usually dwarfed, with the leaves pale, or mottled with light and dark green and much crinkled (Plate III). There is little or no hearting, so that severely affected plants are useless for market. Another common and characteristic symptom is a clearing of the veins, which appear exceptionally transparent when the leaf is held up to the light. Under warm summer conditions, scorching or necrosis is common on mosaic-affected plants, especially on Cos lettuce. Small dead spots appear on the edges of the leaves and elsewhere, and may coalesce into brown dead areas. The disease causes most loss in winter-hardy lettuce overwintered in the open ground. It is sometimes so severe that whole fields are rendered useless and have to be ploughed under.

The virus is carried over in a small number of the seeds, and a few affected seedlings, with mottled leaves, may usually be found in the seedbeds. If the weather is dry and mild, aphids become common and transmit the disease from plant to plant. Consequently, a large proportion of the plants put out in the fields may be already infected with the disease and show severe symptoms in spring. Lettuces planted out in the spring near overwintered crops can also become severely infected, and a chain of successive infections can result unless successive crops are adequately isolated from each other. A few infected plants, usually from infected seed, are often found in greenhouse lettuce crops.

Control

Little infection takes place if the seedlings are raised in frames or under glass before being put out, presumably because aphid infestation is less severe under these conditions. Aphid infestation is less severe if the open-ground seedbeds are in exposed situations, whereas seedbeds near hedges or buildings may become badly infested and much damaged by disease. The edges of seedbeds are specially liable to be badly affected owing to mosaic transmission by incoming winged aphids. A large square seedbed has the smallest exposure of border relative to its size and, therefore, less disease throughout. It may also be worthwhile to discard the outer rows. Transplanting should be done in mild weather and well in advance of really severe weather, if possible, to avoid injury. The transplants may be sprayed in their early stages with TEPP or HETP forced well into the heart. It would also be worth while to spray with demeton-methyl to kill aphids in mid-November after flying has ceased, thus preventing spread during winter and spring.

As far as practicable old and useless lettuce crops should be cleared before following lettuce crops are planted nearby. The virus is found in certain weeds of the daisy family (*Compositae*) growing among lettuce, particularly in groundsel, on which the symptoms can hardly be detected. The virus is also transmitted through a small percentage of the seeds of this plant. It is advisable, therefore, both to practise rotation of crops and to keep down weeds as much as possible.

Lettuce seedlings should not be brought into glasshouses from the open; aphids may be introduced and mosaic may spread disastrously.

Some varieties of lettuce show only mild symptoms when infected, and may produce marketable heads. Other varieties, for example, 'Arctic', 'Feltham King', the 'May Queen' group and summer varieties of crisp lettuce are severely affected and may fail to heart.

Dandelion Yellow Mosaic

A distinct virus transmitted by the aphids *Myzus ornatus*, *Aulacorthum solani* and *A. Myzus ascalonicus* produces yellowish rings and spots on the leaves of dandelion. On lettuce the symptoms are even more severe than those of common mosaic and consist typically of fine brown spots. In glasshouses there is dwarfing and distortion, and out of doors considerable blackening and shrivelling. Affected lettuces and dandelions should be removed and the other measures applied as suggested under mosaic.

Other Virus Diseases

In some seasons, cucumber mosaic is common on lettuces, the symptoms resembling those of lettuce mosaic. For control see this and cucumber mosaic on vegetable marrow (p. 63).

Lettuce virus ringspot is a rare soil-born disease, the symptoms being yellow ring spots, mosaic mottling and distortion. It is caused by a strain of tomato black ring virus.

Big Vein

The chief symptom of big vein is a pale yellowish or blanched vein-banding of the leaves which is usually most apparent near the base of the outer leaves. It is often accompanied by a distortion and a 'savoying' or blistering of the affected leaves. There is often no reduction in size or hearting of affected

plants and frequently the symptoms do not appear until the plant is fully grown.

There has been some confusion between the symptoms of big vein and those of mosaic. Whereas mosaic causes vein clearing and some diffuse mottling of the leaves, big vein causes a broad vein-banding with no mottling or generalized yellowing.

The disease is widely distributed in the U.S.A. and fairly widespread in England. Although the symptoms resemble a virus disease, the disease is associated with a common root fungus (*Olpidium* sp.). It is soil transmitted, being most common where lettuce are grown with little rotation, and appears especially on winter lettuce during the spring.

Rust

Rust (*Puccinia opizii* Bubák) has appeared in the eastern counties. Its alternate stage is on certain sedges (*Carex* spp.).

Tip Burn

Tip burn, a physiological trouble, is described on p. 35.

CELERY

Leaf Spot

Leaf spot* (*Septoria apii-graveolentis* Dorogin and *S. apii* Chester) is the most destructive disease of celery. It occurs all over the country where celery is grown, sometimes causing complete failure of the crop.

There are two distinct forms of the disease. In the first, caused by *S. apii-graveolentis*, numbers of small spots, slightly discoloured and indefinite in outline, are found on the leaves, and numerous minute black fruiting bodies (*pycnidia*) are present on them and on the surrounding green tissue (Plate XII). The second form, caused by *S. apii*, consists of larger leaf spots, light brown and well defined, with only a few very minute black fruiting bodies scattered in the centre.

The small spot form is by far the commoner. It occurs also on the leaf stalks, seed stems, flowers and seeds. It is very destructive, for the leaves may quickly become covered by the spots, and in damp weather disintegrate into a soft wet rot, often called "blight" by growers. The less common large spot form is found only on the leaves and spreads from plant to plant slowly. The dead areas do little damage, although affected leaves may eventually become yellow. This form, which is called "rust" by some growers, rarely, if ever, assumes epidemic proportions in England.

Leaf spot damage is sometimes confused with injury caused by the leaf-mining maggot of the celery fly, but in the latter the large brown blister-like areas usually contain grubs of the fly.

The black fruiting bodies of the leaf spot fungus can be seen easily on infected celery seeds (in reality half fruits) with the aid of a good pocket lens or binocular microscope, especially if the seeds have been kept damp for a day. When infected seeds are sown under moist conditions, the pustules produce gelatinous tendrils of spores which readily infect the cotyledons or seed-leaves when the seed is lifted above ground during germination. If the

* See Advisory Leaflet No. 241.

seedlings are kept wet, clusters of plants with spotted leaves may subsequently appear in the seedbed, and when these are put out in the field they start an outbreak of the disease. The outer and lower leaves are most readily infected, and, from these, spores of the fungus are splashed by raindrops and brushed by workers from plant to plant. Most damage is caused during cool weather with heavy dews when the ground is dry enough to prevent the plants from producing much new growth, but the leaves are moist enough to permit considerable spread of the fungus.

Control

The first essential is to start, if possible, with clean seed. Much of the celery seed on the market, whether home-grown or imported, is unfortunately infected with the fungus to some extent, although many seedsmen now realize the importance of selling only clean stocks.

A warm water treatment gives satisfactory control of celery leaf spot when applied to seed not more than two years old. The seeds are immersed in water at 122°F for 25 minutes and then spread out in thin layers to dry. There may be some reduction in germination of old seed. For details of this process see p. 88 and the Ministry's leaflet "Hot Water Treatment of Celery and Broccoli Seed". If he does not treat the seed himself the grower should obtain from his seedsman a guarantee that the seed he is purchasing has been treated.

The Official Seed Testing Station, Huntingdon Road, Cambridge, is prepared to examine seed samples for the presence of celery leaf spot for a small fee, but it should be realized that a small sample may not be representative of a large bulk of seed.

Three- or four-year old infected seed is usually less dangerous than fresh infected seed, because the fungus loses its vitality with age. The germinating capacity of old seed is, however, likely to be poor, and the fungus may still be alive even on seed eight years old. The disease is more liable to spread when the plants are crowded together and it is therefore advisable not to allow celery seedlings to remain too long in the frames or seedbeds. When they are put out, the rows should not be too close; a space of 3 ft tends to prevent spread across the rows. It is also advisable not to work among the plants when they are wet with rain or dew.

As a precautionary measure the plants should be sprayed with a copper fungicide in the seedbed, before pricking out and before planting out. One per cent Bordeaux mixture, 2 per cent Burgundy mixture, colloidal or cuprammonium copper compounds, or cuprous oxide may be used in conjunction with a spreader (see Copper Fungicides, p. 89). Spraying is also necessary in the field at intervals of about two or three weeks. It should be carried out, if possible, before rainy periods. Dusting with a copper lime dust may also give good control, but more frequent applications are necessary. Dust is best applied in the early morning while dew is still on the leaves. Zineb or nabam plus zinc sulphate has also been used successfully.

If the grower is unable to obtain regular supplies of clean and hot-water treated seed he must himself save seed and carry out the treatment, but this requires every care and attention. He should grow a batch of celery from hot-water treated seed in an isolated situation and spray it at frequent intervals throughout the two years necessary for seed saving. If the plants are then seen to be free from leaf spot the seed should be cleaned thoroughly, separating

it as much as possible from pieces of fruit stalks and other trash, and hot-water treated.

Although there is considerable evidence that in this country most of the infection of celery with leaf spot arises from the seed, decayed plants in the soil commonly carry over the fungus from one season to another. The seed and pricking-out beds should be destroyed soon after the young plants are taken from them, and unwanted plant material should on no account be dumped at the sides of the fields.

Entirely new sites, not overlapping old sites, should be chosen for the seedbeds and pricking out ground. There should be a good rotation in the main fields, with avoidance of overlapping.

Phoma Root Rot

Phoma root rot (*Phoma apiicola* Kleb.) occasionally causes severe loss among celery seedlings. Affected plants develop dark brown or black areas on the root and stem just below soil level, and when they are pulled up the roots break off. According to the degree of attack the tops of the plants may either appear perfectly healthy or the seed-leaves (cotyledons) may droop and the stems assume a reddish-purple colour. Older plants are black just below soil level or the roots may be represented merely by a black stub. As a result, the leaves wilt and the plants appear unhealthy.

The disease is caused by a fungus, the fruiting bodies (pycnidia) of which can be found embedded in the diseased tissues. Although no discoloured areas have been found higher up than the base of the leaf stalks, the seeds also become infected. Under a lens the pustules (pycnidia) on the seeds resemble those of the leaf spot fungus. Golden self blanching varieties seem to be the most susceptible.

Control

Diseased refuse should be got rid of and not turned in or incorporated in the compost heap, and a reasonable rotation should be followed. If seed infection is suspected, seed may be treated by the methods described for leaf spot (p. 43).

Pythium Root Rot (Rusty Root)

Patches of seedlings sometimes wither and the cotyledons or seed-leaves droop. The seedlings come away easily when pulled up and the roots are shrivelled and reddish-brown. The disease is caused by a soil-inhabiting fungus, *Pythium* sp., which attacks the tips of the roots and works backwards.

The trouble is most likely to occur when the seedling frames are constructed on a hotbed of manure and when the same soil has been used several times. It can be prevented by treating the soil with formalin. After the frames have been made up with soil, a solution of 2 per cent formalin should be watered over the surface at the rate of from 2–4 pt per sq. ft, i.e., about 3½–7 gal for a 6 ft × 3 ft light. The heavier watering gives slightly better control of the disease, but makes the soil very wet. The frames are closed for about three days and then kept open except in wet weather and at night. To get rid of the fumes the soil must be stirred well every day for a fortnight with a rake previously dipped in formalin. The seed should then be sown as soon as possible. Any soil subsequently added and any tools used for cultivation should be similarly disinfected.

Soft Rot

Celery soft rot (*Pectobacterium carotovorum* (L. R. Jones) Waldee and other bacteria) is a slimy soft rot, usually brown, caused by bacterial infection which often starts from wounds. When celery is grown in very rich soil, longitudinal splitting of the leaf stalks may occur, and wounding may also result from too heavy earthing up, or from damage by carrot fly or slugs. Soft rot commonly follows all these types of injury.

An unusual type of soft rot observed in dry and warm weather is associated with injury by the drosophilid fly, *Scaptomyza graminum*. This fly chooses the hearts of the plants in which to lay its eggs during dry weather, and soft rot frequently follows the development of the larvae among the tender young leaves. This type of rot spreads less as cooler weather supervenes.

Control

Care should be taken to ensure that the hearts of the plants do not become covered with soil during earthing up. Highly nitrogenous soils should be given applications of potash. Slugs should be kept down by soil treatment when the ground is vacant and by means of baits, and carrot fly should be controlled. Injuries to the plants should be avoided, rotation of crops carried out and diseased plants removed and burned. Drainage should be attended to where necessary.

Cucumber Mosaic

Yellow and green mottling of the celery leaves and stunting of the plants (Plate VII) is caused by the cucumber mosaic virus (p. 60), the disease being identical to that which is known as southern celery mosaic in the U.S.A. Tomatoes, spinach and vegetable marrow are often infected with the same virus and the control measures given under vegetable marrow (p. 63) should be consulted.

Corticium Disease

The leaf-stalks of celery are sometimes covered with the whitish or greyish growth of corticium disease (*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.) and although it can be washed off easily, it is apt to leave rusty marks. Development of the fungus appears to be connected with very soft growth and over-ripeness of the crop. Brown crater-like spots ("crater spot") on the leaf-stalks are sometimes associated with this fungus.

Boron Deficiency

Deficiency of boron may lead to poor growth, with yellowing and dying of the leaves, and brown cracking across the stalks. For treatment, see under Cabbage, etc. (p. 13).

Storage Rots

On celery left in the ground until the winter, the fungus *Centrospora acerina* (Hartig) Newhall can cause a dark green to black rotting of the roots, stem and bases of the petioles. It also causes rotting in storage, in common with *Sclerotinia sclerotiorum* (Lib.) de Bary and *Botrytis cinerea* Fr. Celery from infected fields should be disposed of as soon as possible.

Black Heart

Black heart, in which the centre leaves become black, may be caused by excess sodium, potassium, magnesium or ammonia or deficiency of calcium, and is possibly associated with unusual water tables in Fen soils.

Brown Stem

Brown stem, which causes a browning and pitting of the surface of the outer leaf-stalks, is found especially on celery which has been allowed to remain in the field after maturity. Sometimes it is associated with pithiness, or hollowness of the leaf-stalks.

PARSLEY

Leaf Spot

Leaf spot (*Septoria petroselini* Desm.) occasionally causes a leaf spotting of parsley resembling the leaf spot of celery (p. 42). Control measures to be adopted are similar to those recommended for the latter, including the use of disease-free seed, rotation of crops, wide spacing and, if necessary, spraying with Bordeaux mixture, etc.

ASPARAGUS

Rust

The symptoms caused by rust (*Puccinia asparagi* DC.) must be distinguished from other rusty markings on "buds" (young stems) and "bower" or "fern" (feathery shoots). Its most noticeable features are the production of enormous amounts of rusty brown powder on the bower in late summer and of black streaks on stems and needles in autumn. The resulting premature dying of the bower brings about a severe check to the plants, and in the following year few marketable buds may be produced. The disease has occasionally been epidemic in East Anglia and Worcestershire since 1890.

The rust is found on both wild and cultivated asparagus. The summer (uredo) stage of the fungus produces numerous generations of rusty brown spores which spread the disease extensively. They are followed by the black autumn (teleuto) stage on the ripening bower. These spores remain on the ground throughout the winter on fallen needles and stems. When the young buds appear in the spring these spores germinate, giving rise to secondary spores (sporidia), which are carried by the wind and infect the buds, giving rise eventually to clusters of yellowish pustules which liberate the spring spores (aecidiospores). These complete the cycle by infecting the bower and giving rise again to the summer spores. All the spore stages that have been described are essential for the perpetuation of the rust. The Egyptian or tree onion can also become infected with asparagus rust.

Control

Where there is merely a slight amount of rust, the bower should be cut to the ground early and burned, since early cutting prevents excessive falling of needles bearing autumn spores. It is customary in some asparagus-growing regions to cut the bower several inches above the surface of the soil. Pieces of stem thus remain above the ground over winter. These so-called sticks,

often bear visible spores in late spring. It is essential to collect and burn these sticks when the ground is cultivated in early spring.

All stray asparagus plants should be removed carefully, for stray seedlings or plants in headlands may carry the disease over the winter. Young beds are also important in carrying the disease over from season to season. The bower on these beds is usually not cut until the third year, hence debris bearing autumn spores is apt to remain on the ground throughout the winter. Again, the young shoots or buds from these beds are too small to cut, and the spring stage on them is liable to be undisturbed and to give rise to an epidemic. It might be practicable either to cut all this young bower or to group all young beds together and spray them with Bordeaux mixture.

Violet Root Rot

Violet root rot* (*Helicobasidium purpureum* Pat.) is a prevalent and serious disease of asparagus in certain of the commercial asparagus areas. The roots of the plants become covered with the reddish-violet strands of the fungus, and these radiate in all directions over the root surface. As a result, the bower becomes yellow and dies prematurely, usually in circular areas. Although the fungus may infect first-year seedlings it is usually found on older plants. Spread of the fungus from plant to plant is slow and takes place mainly during late summer, the size of an infected area increasing gradually from year to year.

The fungus found on asparagus can attack carrot, sugar beet, garden beet, mangold, parsnip and potato. It is also found on the roots of dock, bindweed and dandelion, three common weeds of asparagus fields. These and other weeds help to keep the fungus alive in the soil in the absence of asparagus; they were, for instance, apparently responsible for one severe attack that developed when asparagus was replanted after the land had been free from this crop for twelve years.

Control

Efforts have been made to rid contaminated ground of the fungus by means of chemicals, but none of these has been very successful, mainly because chemicals do not readily penetrate some of the heavy soils commonly used for asparagus growing. The most satisfactory method of control is to dig out all the infected roots as carefully as possible, as well as a number of apparently healthy roots on the outside of the affected area. All these plants should be burned, preferably on the spot. The area should then be isolated by sinking pieces of corrugated iron at least a foot into the ground, and the plot should be kept free from asparagus and weeds for several years, Where large areas are affected it may be necessary to grow a non-susceptible crop, such as brassicas of some sort.

BROAD AND FIELD BEANS

Chocolate Spot

Chocolate spot (*Botrytis fabae* Sardiña and *B. cinerea* Fr.) of broad beans and field beans (*Vicia faba*) can be found almost every year from December

* See Advisory Leaflet No. 346.

onwards, but the most serious epidemics take place in spring or early summer, from April to July. Chocolate-coloured spots up to ¼ in. or more in diameter appear on the leaflets (Plate IV). They are more numerous on the upper surface and are either superficial or extend to the lower surface. Streaks, sometimes several inches long, occur on the stems. On the leaf stalks similar streaks may lead to complete collapse. The pods and seed coats also show brownish blemishes. The flowers may become infected and rot off. The most severe symptoms, blackening of the leaves, are caused by *B. fabae*, while slight flower symptoms are usually associated with *B. cinerea*.

Similar spotting may be caused by aphid injury and by certain leaf spot fungi, while exposure to frost may lead to extensive reddish discoloration of the stem bases.

Plants infected in early spring often recover, the new growth being unaffected, but in attacks later in the year the spots may coalesce, causing partial defoliation, blackening and death of plants. The disease is very dependent on weather conditions and is most liable to be epidemic during moist weather.

The fungus is carried over from season to season on the debris from old bean haulms, or haulms in stacks, on self-sown seedlings, and occasionally on seeds.

Control

When the ground is well supplied with potash and phosphates the disease is less likely to assume an epidemic form. Adequate drainage is very important and consequently diseased beans are unlikely to succeed in badly-drained, heavy or water-logged soils. The crop should not be in a too sheltered position, but exposed to the prevailing winds. Where necessary, alleyways may be left in the fields to improve air circulation. Sowings that are too dense are liable to be badly diseased; spring-sown beans are usually relatively free, because the vegetative growth does not provide much shelter at a time when the plants are most likely to be attacked, Weeds should be kept down. Old bean haulms should be burned after threshing.

Where the disease seems likely to become epidemic, spraying with Bordeaux mixture, or with a similar copper fungicide and spreader, may be tried.

Sclerotinia Disease

Sclerotinia disease (*Sclerotinia trifoliorum* Erikss. var. *fabae* Keay) blackens the stem bases of broad and field beans and causes wilting of the plants. A cottony white fungus growth appears in the pith and on the outside of the bases of the plants and seed-like sclerotia or resting bodies subsequently develop. In the following season these produce fructifications and spores which may bring about infection of another bean crop.

Although the fungus appears to be distinct from *Sclerotinia sclerotiorum*, which commonly damages carrot, lettuce, etc. (pp. 19 and 37), it can nevertheless attack lettuce and plants of the pea and bean family, so that it is advisable to avoid growing such crops where broad or field beans have failed owing to this disease.

Rust

Rust (*Uromyces fabae* (Pers.) de Bary) is found every year, but usually appears too late to bring about any appreciable loss. Damage is probably worst

Downy Mildew on Cauliflower Seedlings

Photos: Long Ashton Research Station

White Blister of Brassicas

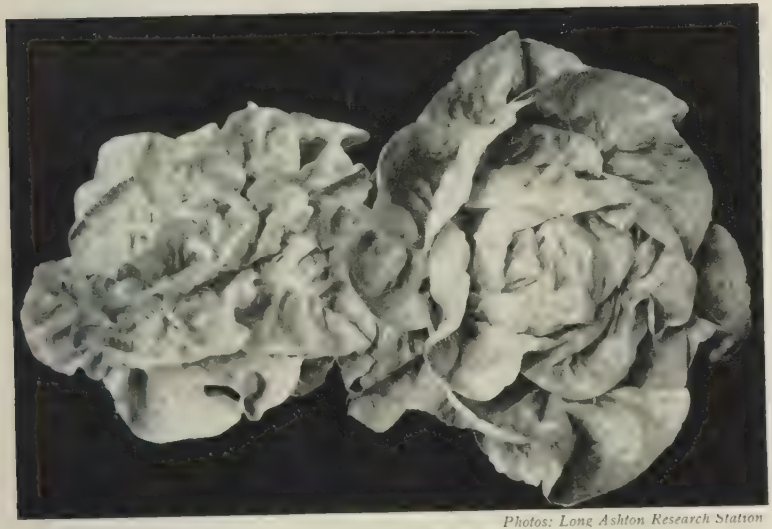
Photo: Long Ashton Research Station

Sclerotinia Disease on Parsnip

Onion Smut

PLATE II

Grey Mould of Lettuce



Photos: Long Ashton Research Station

Lettuce: *Var.* Improved Trocadero

Left: Plant affected with Mosaic. *Right:* Healthy Plant

PLATE III

Club Root on Swede

Photos: Long Ashton Research Station

Chocolate Spot on Broad Bean

Didymella Fruit Rot of Tomato

Ring Spot (*Mycosphaerella brassicicola*)

PLATE V

Tomato Leaf Mould

Tomato Blight

PLATE VI

Halo Blight of Dwarf Bean

Celery Mosaic

PLATE VII

Leek Rust

Cucumber Mosaic on Marrow Leaves

Photo: Long Ashton Research Station

Halo Blight on Dwarf Bean Pods

Anthracnose on Dwarf Bean Pods

Halo Blight on Dwarf Bean Seeds

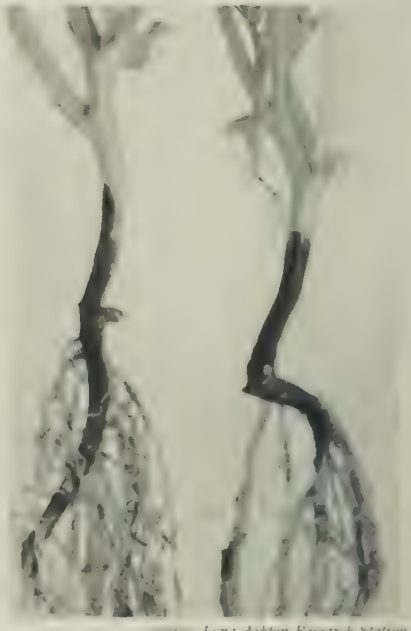
Photos: Long Ashton Research Station

Mint Rust

PLATE IX

Whiptail of Cauliflower (Healthy Plant on Right)

Pod Spot of Pea



Fusarium Foot Rot of Pea

Damping-off of Lettuce (*Corticium solani*)

Foot Rot of Tomato

Photos: Long Ashton Research Station

PLATE XI

Tomato Streak

Leaf Spot of Celery (*Septoria apii-graveolentis*

PLATE XII

where the soil is low in potassium. The fungus may overwinter on old bean straw.

Leaf Spots

There are two leaf spots of broad and field beans which may be confused with chocolate spot, namely, those caused by *Cercospora fabae* Fautrey and *Ascochyta fabae* Speg. respectively. Both of these have grey centres, the former having a slightly raised chocolate-coloured encircling ridge and the latter minute pustular fruiting bodies in the central area.

In net blotch, caused by *Pleospora herbarum* (Fr.) Rabenh., there are grey blotches, with ill-defined, net-like or dendritic margins, bearing olive-brown to black spore masses. The affected older leaflets become brittle and fall off. None of these diseases causes any great damage.

Virus Diseases

Broad beans are affected by broad bean mottle, pea mosaic, pea leaf roll, pea enation mosaic and bean yellow mosaic. The last named can also infect clover, dwarf beans, gladioli, etc. (see p. 51).

The pea leaf roll virus is often common in crops of peas and field beans in south-east England. In field and broad beans the leaves roll inwards and become yellow, thickened and brittle. The plants become stunted, the leaves fall and the growing points die off. The virus is transmitted by the aphids *Myzus persicae* and *Macrosiphum pisi*.

Potassium Deficiency

In soils low in potassium or with an unfavourable potassium/nitrogen ratio the plants become dwarfed, with the internodes short and the growth bunchy. The leaves are scorched and blackened round their margins and the flowers appear prematurely. Under these conditions injury by frost is severe, the lower surfaces of the leaves being puckered and glossy, while in waterlogged soils the base of the stem may be blackened and the lower leaves become yellow and rot off. Such symptoms are usually followed by severe *Botrytis* injury (see chocolate spot).

DWARF (FRENCH) BEANS

Halo Blight

Halo blight (*Pseudomonas phaseolicola* (Burkh.) Dowson) has been known in England since 1930, and sometimes causes much loss, especially in wet weather. The disease derives its name from the characteristic spots which it causes on the leaves. These are semi-transparent and water-soaked, about $\frac{1}{8}$ in. across and each is surrounded by a yellow ring or halo (Plate VII). The spots sometimes coalesce and dry up so that large areas of the leaf may become brown and withered. Occasionally they are very numerous and the characteristic yellow haloes may then be absent.

The bacteria that cause the disease are often abundant under the seed-coat, and infected seeds may have raised blisters usually of a lighter colour than the rest of the seed (Plate IX). These blisters are conspicuous on dark purple seeds such as those of 'Canadian Wonder'. Infected seeds may give rise to seedlings, the growing tips of which are injured or destroyed, a condition

referred to as "snakehead". If these survive, the resulting plants are usually systemically infected, the bacteria having invaded the water-conducting vessels. The leaves are then pale yellow with conspicuous green veins, their appearance suggesting infection with mosaic disease.

When the stems are badly infected some of the leaves or even the whole plant may wilt. This is a striking feature of severe epidemics and may be accompanied by a reddish discoloration of the veins on the leaves, leaf stalks and stems, and the exudation of the bacteria in white slimy masses or tendrils. The bacteria are spattered about by raindrops and infect neighbouring plants.

Infection of the pods results in circular water-soaked spots from which masses of bacteria ooze out (Plate IX). These look like drops of candle grease dropped on the surface of the pods; hence the German name for the disease, which means "grease spot".

Control

There are several ways in which the disease may be kept under control. Seeds showing the characteristic blisters should not be sown. The "picking over" process employed by seedsmen eliminates those most markedly infected, but less severely infected ones are found in most samples. The seeds should not be soaked in water before sowing. This usually leads to general spread of the infection to healthy seeds and results in the seedlings being so severely affected as to be worthless.

The onset of the disease may be greatly checked by removing diseased plants from the fields early in the season, as soon as they are seen. A second roguing should be carried out a week later. Roguing is particularly important in crops on which it is intended to use overhead irrigation. The disease can be carried over from season to season by infected debris incorporated with the soil. It is advisable therefore to remove and burn diseased plants at the end of the season, and if possible to select a different piece of ground for dwarf beans each year.

Field trials have indicated that there are great differences in the resistance to leaf and stem infection of the varieties grown in England. Practically all varieties with purple seeds resembling 'Canadian Wonder' are highly susceptible. Those with speckled seeds resembling 'Early Prolific' are also very susceptible except the valuable early resistant variety, 'The Prince'. Those with black and white seeds resembling 'Magpie' are mainly resistant, and to a less extent those with black seeds. The stringless podded canning sorts such as 'Keeney's Stringless Refugee' are also resistant. Varieties resistant to leaf and stem infection are not necessarily resistant to pod infection; the English varieties are all about equally susceptible to pod infection. In New Zealand good results have been got by spraying with Bordeaux mixture (6–8–100) even when the plants are heavily infected, but this causes some hardening of the foliage. Streptomycin sulphate at about 75 p.p.m. has also been successful.

Foot Rot

Foot rot (*Fusarium solani* f. *phaseoli* (Burk.) Snyder & Hansen) is prevalent in Worcestershire and has been found in other parts of England. The term dry root rot is applied to the shrivelled appearance of the roots and bases of the stems of affected plants. This is always accompanied by a reddish or reddish-

brown discoloration. The disease may also be recognized by an abnormally early yellowing of the foliage, beginning with the lowest leaves and proceeding upwards about the time the first pods are developing. In severely contaminated soils the plants are poor and stunted and the later pods do not develop. In such cases and in dry seasons the yield may be reduced by about half.

Control

The disease is very difficult to control. Long rotations are suggested, and fields in which the soil is known to be badly contaminated should be avoided. Affected plants should not be ploughed in, but should be collected and burned. Certain strong growing varieties, such as the 'Flageolet' types, are capable of throwing out fresh roots at soil level above the affected areas and thus are able to outgrow the disease to some extent. Nitrogenous top dressings and ridging up the soil towards the plants during cultivation may be helpful. Some breeding work for resistance has been done in the U.S.A. and elsewhere.

Virus Diseases

In bean common mosaic the leaves are ruffled and mottled with dark and pale green areas, the pale colour being concentrated around the margins, which are curled downwards. The leaves and the whole plant are reduced in size. The pods are not usually strikingly affected. The disease is carried over in the seed and transmitted from plant to plant by greenflies.

Another virus disease, bean yellow mosaic, also occurs in England. Here the leaves are malformed and mottled with green and yellow areas. The pods may be considerably distorted. This virus is not transmitted in the seed and, in contrast to common mosaic, it affects red clovers and broad beans, some non-legumes, gladiolus and freesia, being commonly affected.

Varieties which are hypersensitive to the virus at high temperatures may show a brownish-black discoloration of the vascular tissues of all parts of the plant.

Control

Varieties resistant to bean common mosaic are in use in the U.S.A. and seed producers are required to remove infected plants. Yellow mosaic is not seed-borne and infection usually comes from nearby gladiolus plantings or clover fields.

Rust

Rust (*Uromyces phaseolorum* de Bary) has been observed on dwarf and climbing French beans and on runner beans in England. Brown to black spots appear on the leaves. The disease can be controlled by sulphur dusts or sprays.

Anthracnose

Anthracnose (*Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav.) is prevalent in this country only during wet and cool summers. It affects the stems, leaves and pods. On the stems it forms elongated dark brown sunken cankers, which may lead to withering of the upper leaves. Parts of the veins on the under surface of the leaves become reddish-brown and neighbouring parts of the leaves may shrivel up.

On the pods small reddish-brown spots are produced, and these become enlarged to somewhat circular depressions, bordered with dark brown (Plate IX). Under moist conditions slimy masses of pale brown or pinkish spores develop on these spots. The fungus often passes through the pod and attacks the seeds, producing dark spots on light-coloured seeds and less prominent markings on dark-coloured ones.

Control

Anthracnose is not usually serious enough in England to warrant control measures unless weather conditions are exceptional. Where it does occur, infected refuse should be destroyed and dwarf beans should not be grown on the same soil for some years. In the U.S.A. the disease has been practically eliminated by growing most of the seed beans in the semi-arid western regions. None of our English varieties of dwarf beans seems to be very resistant to anthracnose. Elsewhere, various resistant varieties have been recommended, and zineb or captan sprays have been successful.

Grey Mould

In wet seasons and in poorly drained soil the pods of dwarf beans are often attacked by the common fungus *Botrytis cinerea* Fr., which covers them with a grey fungus growth. It is important to reject all the affected pods before the beans are sent to market otherwise the trouble may spread during transit.

RUNNER BEANS

Halo Blight

Stands of runner bean seedlings are often found to be severely dwarfed, yellow and distorted. This is usually due to the common practice of soaking the seeds in water before sowing. As explained in the case of dwarf beans (see p. 49), the disease is spread in this way, so that the seedlings become systemically infected and make little further growth. To prevent an epidemic on older plants, such seedlings should be pulled out and burned.

Wilt

Wilt (*Fusarium oxysporum* Fr.) is found in parts of Worcestershire and has occasionally been recorded elsewhere. Diseased plants may either occupy well-defined areas or may be scattered throughout the fields.

The symptoms may appear first on the primary leaves, the margins of which become yellowish green. Finally the whole leaf becomes dry and brittle. The margins of the later compound leaves roll inwards and the leaflets droop. These symptoms appear progressively on the younger leaves, until finally the whole plant withers and dies. If the stem is cut lengthwise, a dark brown discoloration of the woody strands can be seen, often traceable up into the youngest leaves and down into the main and lateral roots. This is very characteristic of the disease.

The fungus invades the plant through cracks at the base of the stem or on the larger roots. Its pink fructifications may be found on the surface of the dead stems and sometimes on the pods. The fungus has not been detected on seeds from such pods, but it is possible that the disease may occasionally be transmitted in this way.

Control

The fungus is undoubtedly carried over from season to season on infected debris and in the soil, and it is therefore advisable to burn infected material at the end of the season and to give the fields a few years' rotation with non-leguminous crops. The wilt is most troublesome in badly-drained soils and, where necessary, attention must be paid to drainage. In variety trials on contaminated soil, 'Giant Painted Lady' appeared to be fairly resistant.

Sclerotinia Disease

Sclerotinia disease (*Sclerotinia sclerotiorum* (Lib.) de Bary) sometimes attacks runner beans at the base of the main stem or of the branches. A white fungus growth and characteristic large black resting-bodies develop on the affected areas and cause the upper parts of the plant to wilt.

The same fungus commonly attacks carrots, lettuce (pp. 19 and 37), etc., and long rotations free from these crops are recommended.

Foot Rot

Runner beans are sometimes affected with foot rot (p. 50), but there is usually little check to growth.

Leaf Spot

The fungus *Ascochyta boltshauseri* Sacc. causes dark zonate lesions on leaves and pods of runner and dwarf beans. The disease is reported from East Anglia.

PEAS

Pea Wilt

Observations in this country have confirmed the existence of St. John's disease, a disease complex so-called because, in Holland, the pea plants tend to die off about St. John's day, 24th June. It can be split into three components: wilt (caused by *Fusarium oxysporum* f. *pisi* (Linford) Snyder & Hansen) and to a lesser extent, *F. oxysporum* f. *redolens* (Wollenw.) Gordon), foot rot (caused by *F. solani* f. *pisi* (Jones) Snyder & Hansen) and the two acting together. Early failures, from mid-May to mid-June, are usually due to wilt, whereas from mid-July they are due to foot rot. Simultaneous infections are common in late June. Root eelworm may also be a component of the whole complex.

In true wilt disease, caused by *F. oxysporum* f. *pisi*, the plants are rather stunted, with the lower, and usually also the upper leaves, turning yellow and rolling under along their mid veins. A greyish bloom precedes the yellowing and the rolled leaves are brittle and easily detachable from the main stem. The most severe symptoms occur as the flowers are forming. Diseased plants rarely bear full pods, but wither and die quickly.

A pale orange to deep brick red discoloration of the vessels can be seen when the stem is slit lengthwise.

Control

Peas may be grown on infected land provided a wilt resistant variety is used, such as one of the following popular varieties: 'Big Ben', 'Canner No. 99', 'Canner's Perfection', 'Dark Skin Perfection', 'Freezer 37', 'Kelvedon Monarch', 'Progress No. 9', 'Shasta', 'Victory Freezer', 'Zelka'. The following

are susceptible to wilt: 'British Lion', 'Feltham Advance', 'Feltham First', 'Gregory's Surprise', 'Kelvedon Wonder', 'Laxton's Progress', 'Meteor', 'Radio', 'Onward', 'Rondo', 'Thomas Laxton (ordinary stock)'*.

Fusarium Foot Rot

A foot rot (*Fusarium solani* f. *pisi* (Jones) Snyder & Hansen) of peas has been recorded from many parts of the country. When the plants are forming their first pods the lowest leaves begin to wither and finally the plants die off, usually in well-defined patches. On the diseased plants there are chocolate-brown or purplish streaks or markings at the stem bases, the roots are coloured brown or black and there is poor development of root nodules (Plate X). When temperatures are high the woody strands in the interior of the roots may be coloured reddish-brown.

The causal fungus is similar to that causing foot rot of dwarf beans, except that the pea strain of the fungus does not attack dwarf beans and the dwarf bean strain does not attack peas.

The disease is apparently favoured by heavy rainfall during the early growth of the plant and by rather high temperatures later. It is found both in well-drained and badly-drained fields and on heavy and light soils. The disease is most prevalent where peas are grown on the same ground year after year with little attempt at rotation. This is also true in other countries, such as the eastern states of the U.S.A. and the reclaimed regions of Holland and Germany, where other similar diseases of peas, and especially wilt diseases, also occur.

Control

It is difficult to control the disease. The use of new ground or a rotation of several years is advisable wherever possible. Protective seed dressings may discourage early infection of seeds and seedlings. Varieties of peas with round seeds are usually more susceptible than those with wrinkled seeds, apparently because the stem at soil level is more easily penetrated by the fungus. Certain varieties with tough stems, such as 'Dwarf Defiance', 'Stratagem' and 'Surprise', appear to be fairly resistant.

Applications of dung increase the severity of the disease, while inorganic nitrogenous fertilizers (especially sulphate of ammonia), at the rate of several hundredweights per acre, enable greater yields to be obtained on contaminated soil.

Pea Root Eelworm

Peas affected with fusarium root rot are very often attacked at the same time by pea root eelworm, *Heterodera gottingiana*. When this happens small pinhead-like cysts about the same size and shape as lobelia seed, at first white and afterwards yellow to chestnut brown, are found on the roots, late in the development of the plants. The disease symptoms are intensified and the plants are dwarfed, yellow in colour, and die off prematurely, as do those affected with fusarium foot rot alone.

The strain of the eelworm in question is confined to peas, broad beans, field beans, vetches and lupins. Among leguminous crops, the following are not attacked: runner and dwarf beans, sweet peas, clovers and lucerne.

* For a more complete list see "Reaction of Varieties to Pea wilt", Miscellaneous Publication No. 7. Obtainable from Pea Growing Research Association Ltd., Yaxley, Peterborough.

Control

There is no known economic method of direct control of pea eelworm. In the interests of reducing the incidence of outbreaks, the interval between host crops should be three years at the absolute minimum. An interval of seven to eight years is much safer.

Pythium Foot Rot

A distinct foot rot (*Pythium ultimum* Trow) has been recorded from one pea-growing district in Wiltshire. Large patches of peas die off, the bases of the stems being water-soaked and the leaves yellowish and wilted. This disease appears to be identical with one prevalent and troublesome in New York State.

It is well known in the area in question that adequate rotation is required for a healthy pea crop; this, combined with burning the diseased haulms, offers the chief hope of control.

Root Rot

Root rot (*Aphanomyces euteiches* Dreschl.) occurs in many districts, and causes considerable losses, especially in heavy or poorly drained soils. The roots are decayed and the base of the stem is softened, water-soaked and slightly discoloured. A rather characteristic feature is that when an affected plant is pulled up the inside of the root comes away as a fibrous string.

The symptoms on the above-ground parts of the plant resemble those associated with fusarium foot rot. There is a distinct check to growth and often yellowing of the leaves from the base of the stem upwards.

Control

Suggested control measures include adequate rotation and improvement of drainage where necessary. In the U.S.A., application of balanced fertilizers, especially those containing quickly available nitrogen, in the furrow with the seed, has resulted in greatly increased yields on contaminated land.

Black Root Rot

Black root rot (*Thielaviopsis basicola* (Berk. & Br.) Ferraris) closely resembles fusarium foot rot. It affects mainly the tap root, which is turned black, and leads to stunting and death of the plants. The disease is found mainly in limestone districts or where lime has been applied to the soil; the fungus is most active in cool weather. Rotation of crops, drainage and the use of acid fertilizers such as sulphate of ammonia and superphosphate appear to be the most likely means of control.

Leaf and Pod Spot

In England, leaf and pod spot (Ascochyta disease) of peas may be caused by three closely related, but distinct fungi, *Ascochyta pisi* Lib., *Mycosphaerella pinodes* (Berk. & Blox.) Vestergr. and *Ascochyta pinodella* L. K. Jones. The first two are much the commonest.

The spots caused by *Ascochyta pisi* are pale brown, surrounded by a darker margin, circular, a quarter of an inch or less in diameter and slightly sunken (Plate X). *Mycosphaerella pinodes*, on the other hand, produces smaller purplish-brown spots, often with concentric rings, on the leaves, purplish streaks

on the stems, and smaller irregular purplish spots, which may coalesce into diffuse purplish markings, on the pods. The leaf spots caused by *Ascochyta pinodella* resemble those due to *Mycosphaerella pinodes*, but are not so abundant.

The damage to foliage and pods by these fungi may be severe in very wet seasons. Infection of the pods almost invariably leads to infection of the seeds, a few of which may become mottled with sunken brown or purple spots. Seeds stained in this way are useless to canners, and affected crops cannot command good prices. Infected seeds give rise to diseased seedlings and much damage may result to pea seedlings in this way.

Young shoots attacked by *Ascochyta pisi* become infected from the cotyledons or seed-leaves, and the result is a "seedling blight" in which the tip of the stem and the young leaves become covered with the circular or elliptical pale brown spots characteristic of the fungus. Those on the stem often penetrate so far into the tissues that the top is killed.

Mycosphaerella pinodes and *Ascochyta pinodella* have quite a different effect on the seedlings. While infection again originates from the cotyledons, a severe foot rot is produced. The stem and root immediately above and below the seed-leaves become first dark brown and later black, and death of the seedlings usually follows.

Although seedsmen reject the great majority of discoloured seeds in the course of cleaning, peas may be infected without showing any external symptoms, and consequently there usually remains in commercial samples a proportion which are affected. When these are kept moist for a few days a copious growth of the fungi is produced. Severe infection of a crop can usually be traced to infected seed, but all these fungi may also persist on debris in the ground from which spores may infect the young seedlings.

Control

Where a crop has been badly infected with leaf and pod spot it is advisable to burn the haulms and not to use the ground again for peas for several years. Seed produced in countries with dry climates or in dry parts of England are likely to have only a small percentage infection. Elsewhere, spraying with thiram (1½ lb per 100 gal) has been used with some success. The carry over of the disease may be slightly reduced by seed treatments (p. 80), and experiments on improved methods to this end are in progress.

Powdery Mildew

Powdery mildew (*Erysiphe polygoni* DC.) covers the leaves and pods with white powdery patches. It is most prevalent in rather dry weather when a considerable difference between day and night temperatures results in heavy dews. The disease is most liable to be troublesome on late varieties towards the end of the season and in sheltered situations. In gardens, dusting with finely powdered sulphur may be tried.

After a crop has been picked, diseased haulms should be removed quickly to prevent infection of subsequent crops.

Downy Mildew

Downy mildew (*Peronospora viciae* (Berk.) Casp.) brings about a greyish-brown growth on the under surfaces of the leaves and on the pods. Diseased pods often have no seeds and contain masses of spores. Young plants are some-

times attacked early in the season and their growth greatly checked. The fungus is very susceptible to desiccation and severe epidemics take place only during moist weather.

As the resting spores of the fungus may remain in the soil from one planting season to another, the haulms should be burned, where the disease has occurred, and another kind of crop grown the following season.

Stacks of peas affected by downy mildew should be threshed before the next season's crop begins to emerge, to avoid risk of spreading the disease.

No chemical method of control can be confidently recommended, although in Holland promising results have been obtained with zineb at 3 lb per acre. If the disease proves troublesome, varieties which have been found to be resistant in the area should be considered. Among threshed peas, for example, the marrowfats 'Big Ben', 'Emigrant' and 'Zelka' are susceptible while the blues, 'Rondo' and 'Unica', are fairly resistant.

Grey Mould

In wet seasons grey mould (*Botrytis cinerea* Fr.) may spread from the decaying flowers to the pods, causing a pod rot and staining of the seeds. "Chalky" seeds are often due to this fungus.

Pea Virus Diseases

Pea mosaic causes a very marked mottling of the leaves with pale green or yellowish-green depressed areas, usually between the veins. The pods are not affected. The virus is not carried in the seed. It is transmitted by common aphids found on peas. It infects also sweet peas, on which it produces a mottle and flower breaking, and broad beans, on which it produces a bright yellow and green mottle.

Pea enation mosaic produces severe mottling, crumpling and savoying of leaves and stipules, and yellow to white somewhat transparent spots on the leaves. On very susceptible varieties necrotic spots develop, with proliferations. Pods are rough, ridged and wrinkled. The virus is not seed transmitted. It is carried by several common aphids. It affects also broad beans and lucerne.

Bean yellow mosaic causes at low temperatures a chlorotic spotting and mottle with extreme rosetting, while at higher temperatures there is necrosis of the stem, wilting and collapse. The virus is carried by common aphids but not seed transmitted. Sweet pea, broad and dwarf beans, and clovers are also affected.

Pea leaf roll causes leaf curling with yellowing of the apical leaves, an erect habit, and browning of the wood vessels. Carried by *Myzus persicae*, this virus also affects field and broad beans.

Control

Some control of virus diseases is obtained by the routine spraying of field crops with DDT emulsion. In Holland, varieties are available resistant to top yellows (pea leaf roll).

Marsh Spot

Marsh spot, so-called because of its common occurrence on certain types of marshy and other soils, is a disease of peas caused by a deficiency of manganese. The circumstances under which manganese deficiency becomes apparent are described on p. 26. Affected seeds usually appear quite normal

externally, but when they are cut across, a more or less rounded, well-defined brown spot is found in the centre of the seed-leaves or cotyledons. When these seeds are sown they may not develop at all or the main shoot of the seedling may die soon after germination, further growth being continued by the development of lateral shoots. The seeds are most markedly affected, but patches of yellow plants may occur in the field, the areas of the leaf between the veins becoming yellow. The trouble is of most importance in peas harvested dry, since the spot develops late. Green peas or vining peas for canning and quick freezing are seldom severely affected.

A condition of the seed heart known as hollow heart or cavitation and resembling marsh spot, is also associated with abnormal seedlings. The cause is unknown.

Control

If symptoms of manganese deficiency are seen, the crop should be sprayed with manganese sulphate at the rate of 5 lb per 100 gal of water per acre, about 18 days after the first flowers appear, and again seven days later. If the land is known to be deficient in manganese, one application, at these rates, towards the end of flowering, should prevent marsh spot in the seeds.

Pre-emergence Damping-off

The rotting of seeds which takes place below ground, especially in wet soil, during the winter and spring months is known technically as pre-emergence damping-off. Soil fungi, especially species of *Pythium*, attack the seeds and the seedlings before they emerge above ground.

This rotting may be prevented to a large extent by the use of chemical seed dressings. Organo-mercury or cuprous oxide dressings were formerly popular, but commercial peas are now usually treated with thiram or captan, which are relatively non-poisonous, in contrast to organo-mercuries which may constitute a hazard if used on the farm.

A combined fungicide-insecticide dressing is recommended where very high populations of wireworm occur. These dressings may increase the emergence or "stand" of autumn and winter-sown seeds by as much as two or three times, but sowings after April are not likely to benefit greatly when conditions for germination become much more favourable.

Injury sometimes follows the application of some seed dressings to peas. Organo-mercury dressings are unlikely to injure the seeds unless they have been damaged, but the growth after germination may be retarded if they are sown in very warm and dry weather. Injury may result from the use of cuprous oxide as a seed dressing in the following circumstances. Some varieties, especially the small round-seeded types, such as 'Eclipse' and 'Alaska', 'Charles the First', 'English Wonder' and 'Bountiful', are rather susceptible to injury, but only in very dry soils will they fail to germinate. Growth after germination is occasionally retarded to some extent, but in early-sown varieties this is not regarded unfavourably by some growers because the plants may then be less liable to injury by frost.

CUCUMBER AND MELON

Gummosis

The most characteristic symptom of gummosis (*Cladosporium cucumerinum* Ell. & Arth.) is gumming of the cucumber fruits. Small, grey sunken spots

appear on the fruits when they are still undeveloped. These enlarge rapidly, and from them a gummy liquid exudes. A dark green velvety layer, consisting of fungus spores and mycelium, soon covers the diseased areas, which shrink and frequently crack open, exposing the white flesh beneath. The fungus occasionally attacks the leaves, producing large numbers of small light brown irregular spots, and also forms slight cankers on the stems.

Control

The disease is worst under very wet and cool conditions. Diseased fruits should be removed and burned, more ventilation should be given, and a little more pipe heat may also be desirable. Salicylanilide, at low volume, through a compressor, or zineb or captan at 2 lb per 100 gal, or zineb dust have been reported to give some control. Copper-petroleum sprays can also be used when mildew is also present. The houses should be disinfected before another crop is planted. Some new Dutch F 1 hybrids, such as 'Green Spot', appear to be resistant.

Mildew

Mildew (*Erysiphe cichoracearum* DC.) is fairly common on cucumbers in greenhouses, and can retard the plants considerably. It appears as small, greyish spots which later become covered with white fungal growths. In severe attacks, the whole plant assumes a white, mealy appearance. The fungus can infect wild *Sonchus* spp.

Control

Mildew can be checked by attention to ventilation, particularly by avoiding draughts and severe fluctuations in humidity. Attacks can be controlled by spraying, dusting or smoking with Karathane, by spraying with colloidal copper-petroleum sprays or frequent dusting with sulphur dusts. Dust or smokes of Karathane have least tendency to harden the plants, but high volume sprays may be required in mid-season to effect control. Karathane should not be used in conjunction with white oil.

Grey Mould

Grey mould (*Botrytis cinerea* Fr.) produces a dense, grey velvety fungus growth on the stems and tips of the young fruits and may cause severe damage under very humid conditions. It can be prevented by attention to ventilation and general hygiene.

Soft Rot

Soft rot (*Pectobacterium carotovorum* (L. R. Jones) Waldee and other bacteria) sometimes causes a soft, brown rot of the base of the stem just above and below soil level. The disease, which is found usually on fruiting plants, but occasionally on quite young plants, is induced by wet conditions at the stem base. This may be avoided by making conical-shaped beds. The base of the plant should be kept as dry as possible and water should not be poured directly on the stem. Attacks which are not too far advanced may be checked by dusting the base of the plant with a copper lime dust. Dung containing vegetable refuse should not be used for preparing or mulching cucumber beds.

Verticillium Wilt

Verticillium wilt (*Verticillium albo-atrum* Reinke & Berth. and *V. dahliae* Kleb.) affects cucumbers, as it does tomatoes, during early spring and autumn when

temperatures are low. The leaves become yellow from the base of the plant upwards, and the whole plant wilts. If the stem is cut open longitudinally, the wood is seen to be discoloured brown.

Control

If only a few plants are affected, they should be removed and burned, since the fungus will produce spores on dead stems which may infect healthy plants. If many plants are affected, the houses should be shaded and the atmosphere kept moist by frequent syringing. Care should be taken not to water the beds heavily since this may lead to waterlogging and consequent death of the roots. Top dressing the beds to promote the production of new roots is also beneficial. Verticillium wilt is favoured by low temperatures and therefore the houses should be kept as warm as possible.

In cases of persistent wilt it may be necessary to build concrete troughs for cucumber culture, since they can be cleaned out easily and sterilized at the end of the season.

Fusarium Wilt

Symptoms similar to verticillium wilt may be produced by a species of *Fusarium*, but they develop rapidly only at high temperatures. The infected plants should be removed, together with the soil around the roots. The holes may then be filled with a mixture of 5 parts soil and 1 part lime or watered with a solution containing 1 oz copper sulphate (bluestone) in 2 gal water, or with Cheshunt compound, and replanted. Care should be taken in the disposal of all diseased material, and soil sterilization may be necessary at the end of the season if many plants have been attacked.

To keep the stem dry and to protect it from disease it can be surrounded by a metal collar or a short drain pipe.

Fusarium oxysporum f. *melonis* (Leach & Currence) Snyder & Hansen has been recorded on melons in England.

Cucumber Mosaic

Cucumber mosaic* virus is common on cucumbers particularly when they are grown in the open. The same virus infects a great many other plants including marrow, spinach, tomato and many ornamental garden plants.

The symptoms are a yellow mottle on all the leaves developed after infection, accompanied by considerable leaf distortion and dwarfing. The stem is much dwarfed, the internodes being shortened. Plants infected early have a bushy non-climbing habit, with the leaves lying close to the ground in a rosette-like clump. The fruits are usually light yellowish-green with spots of dark green, but are sometimes almost white with irregular green areas. A distinctive feature is the distortion of the fruits, which are misshapen or have raised warts of dark green.

Control

The mosaic virus may be seed-transmitted to a slight extent, and it is therefore advisable to save seed only from healthy plants. Seedlings should be examined, and any with a conspicuous mottle discarded. It should be noted, however, that there is frequently a slight flecking of cucumber leaves not due to virus infection. If infected plants are seen at a later stage, they should

* See Advisory Leaflet No. 340.

be dug up or cut off. The knife used should be cleaned with a two per cent Lysol solution, and the hands washed with soap and water.

Aphids, which transmit the virus, should be destroyed by cleansing the empty houses by means of a BHC aerosol, smoke or spray several days before planting. If, however, the aphids become troublesome on the plants, malathion aerosols or sprays or nicotine fumigation may be employed. Infection may come from marrows or weeds outside the houses (see below) or from ornamental plants such as primulas grown in neighbouring greenhouses.

There is another virus disease of cucumbers known as green mottle mosaic (caused by a strain of tobacco mosaic) which is occasionally encountered. The symptoms are vein clearing, a dark green mottle accompanied by blistering and distortion, especially of the young leaves, and stunting of the plant. The fruit is usually unmarked, except for a slight mottle. It is also transmitted.

Anthracnose

Anthracnose (*Colletotrichum lagenarium* (Passer.) Ell. & Hals.) sometimes causes a damping-off of cucumber seedlings, but does not usually appear on the plants until March and April, when they are well established. Pale green water-soaked spots are formed on the leaves. These enlarge rapidly and become reddish-brown in the centre, surrounded by a yellowish water-soaked zone. Finally, several blotches coalesce and the leaf dries up, so that in the final stage the leaves have a scorched appearance and are covered with spots. The minute fruiting pustules of the fungus are borne on the upper surface of the leaf.

Sunken elongated water-soaked areas also appear on the leaf stalks and stem, and may girdle the latter so that the plant wilts. These stem cankers quickly become dry, powdery and black, and produce enormous quantities of pink spores. Similar pale green sunken areas are produced near the tips of the fruits. They finally crack and expose the internal tissues, while the fruit becomes yellow and dies off. In this case, too, fruiting pustules, at first pink and then dark brown or black, develop on the diseased patches.

The fungus can live on straw, wood, paper, etc., and may be introduced in contaminated manure or in the water supply. It can be spread by contact with clothes of workers or in the course of watering the plants.

Control

The empty houses should be sprayed thoroughly with formalin or with emulsified cresylic acid (p. 85) during the winter months. The liquid should be directed especially on to any decaying pieces of woodwork. During the growing season, the air should not be allowed to become saturated and stagnant, but ventilation should be given whenever possible, while a constant temperature should be maintained day and night.

Affected plants should be sprayed during the early stages of attack, and preferably in the evening, with a colloidal sulphur suspension containing a spreader. All spotted leaves should then be removed and burned, and a little ventilation given. This procedure should be repeated at weekly intervals until the disease is suppressed.

Any plants badly marked on the stems or leaf stalks should be removed and burned, otherwise a wholesale infection of the other plants may follow.

Blotch

With the introduction of the variety 'Butcher's Disease Resister' and modern methods of soil sterilization blotch (*Cercospora melonis* Cooke), which used to be very destructive, has become comparatively rare. Very small, pale green, water-soaked spots appear on the upper surface of the leaf. These quickly increase in size and number, becoming first grey and then brownish. The spots are well-defined and irregular in shape. The leaves decay rapidly.

Control

Where the disease has been epidemic it is advisable to burn the plants, to disinfect the houses very thoroughly with cresylic acid or formalin (p. 84) and to steam sterilize the soil. If, in spite of these precautions, diseased leaves are seen, they should be collected and burned; the temperature should be reduced and more ventilation given. Spraying with sulphur compounds could be resorted to in severe cases. The only certain means of avoiding the disease is to grow the variety 'Butcher's Disease Resister', which has given satisfactory crops even in badly infected houses.

Angular Leaf Spot

Angular leaf spot (*Pseudomonas lachrymans* (Smith & Bryan) Carsner), a bacterial seed-borne disease has occasionally been seen in this country. Water-soaked angular spots which later become brown or chalky, appear on the leaves, and similar water-soaked spots, often followed by a soft rot, occur on the fruits.

Stem and Fruit Rot or Black Rot

The symptoms of stem and fruit rot or black rot (*Mycosphaerella citrullina* (G. O. Smith) Grossenbach) are water-soaked areas on the stems, branches and fruits, later becoming grey and shrivelled, and covered with minute dark brown or black fruiting bodies. Severe wilting may take place, and rotting of the ends of the fruits, sometimes with a gummy exudate.

Diseased shoots and fruits should be pruned off and syringing stopped temporarily. At the end of the season the crop should be removed entirely the soil steamed, and the houses thoroughly cleaned.

Foot Rot

Foot rot of cucumbers is usually caused by the fungus *Corticium solani* (Prill. & Delacr.) Bourd. & Galz. Diseased plants and some of the surrounding soil should be removed.

Tap Root Rot

This trouble starts as a small brown area on the tap root, which increases till it is completely rotten and the plant wilts. It may be initiated by root damage or drying out in the pot stages or by high ammonia or manganese in steam-sterilized soil, and also occurs in cold wet and consolidated beds. *Pythium* or *Fusarium* spp. may be present.

Fruit and Stem Rot

Fruit and stem rot, caused by various species of *Pythium*, has been recorded from several parts of the country. Cuprous oxide at $\frac{1}{2}$ oz per gal has been used successfully in controlling the rot.

Withering and Distortion of Fruits

Withering and distortion of the fruits may be caused by over-watering and consequent poor root development. The fruits should be trimmed, and the houses should be ventilated and the beds dried out, the foliage being maintained by syringing. After ten days, the beds should be top dressed with a good compost, and watered. The houses should then be closed again and the usual forcing procedure continued.

VEGETABLE MARROW, PUMPKIN, RIDGE CUCUMBER AND GHERKIN

Cucumber Mosaic

Vegetable marrows are often infected with a mosaic disease caused by the cucumber mosaic* virus (see p. 60) (Plate VIII). The symptoms are very marked mottling, taking the form of pale yellow markings which usually run in wavy lines or circles, and considerable puckering of the leaves. Affected shoots have shortened internodes and tend to branch. The diseased fruits are mottled and covered with circular wart-like areas. All the young leaves and shoots of an affected plant ultimately show the symptoms, but the older leaves remain apparently normal. Much of the young fruit dies off without developing. These symptoms are also found on gherkins, which are very commonly affected.

The virus is apparently transmitted through a small percentage of the seeds, and is subsequently carried from plant to plant by aphids and possibly by the hands of the workers touching the plants. It also infects cucumbers, spinach, tomatoes and celery (p. 45) as well as certain ornamental plants, including aster, delphinium, polyanthus, and weeds of the marrow and potato families. It may therefore reach the marrows each year either through seed infection or from any of the perennial host plants mentioned.

Ridge cucumbers can also be infected with the virus which causes, in addition to a leaf mottle, rapid wilting, shrivelling and death of the plants.

Control.

Marrows should be grown at a distance from any other host plants. Any plants that become infected should be removed immediately and burned. Seed should be kept only from healthy plants. Weeds should be kept down and any white bryony in neighbouring hedgerows should be grubbed up.

Mildew

Mildew (*Erysiphe cichoracearum* DC.) is usually common on the leaves and stems of marrows in the autumn, turning them white and eventually causing the plants to wither prematurely. The crop is thereby much reduced.

Good control may be obtained by dusting the plants with ground sulphur, green sulphur, or Karathane dust as soon as the disease appears, and subsequently at intervals of about a fortnight.

Grey Mould

Grey mould (*Botrytis cinerea* Fr.) attacks the flowers of some kinds of marrows and pumpkins, and the rot then spreads into the fruits. In varieties liable to

* See Advisory Leaflet No. 340.

attack, some of the leaves should be picked off to allow sun and air to reach the fruits and any rotting flowers or fruits should be removed immediately.

Gummosis

Gummosis (*Cladosporium cucumerinum* Ell. & Arth.) (p. 58) has caused severe damage to marrows, gherkins and ridge cucumbers in the open. Large dark spots occur on the fruits, accompanied by gumming and cracking. Infected material should be burned, and seed should not be saved from diseased fruits.

Marrows grown in frames or pits are subject to some of the diseases that affect cucumbers under glass, such as anthracnose and blotch (pp. 61 and 62).

MINT

Rust

Rust (*Puccinia menthae* Pers.) is very common wherever mint is cultivated. The diseased plants can be distinguished in spring and early summer by their abnormally thickened and distorted shoots. These bear considerable numbers of minute orange cup-shaped structures, the so-called cluster cup or aecidial stage of the fungus (Plate IX). These produce innumerable spores which infect other mint plants. As a result, pustules of yellow spores (the summer spores or uredospores) are produced on the leaves, and spread the rust far and wide throughout the summer. Later on, in the autumn, black spores (teleutospores) are formed and these are washed into the soil and become lodged between the bud scales where they germinate in winter and early spring, giving rise eventually to the cluster-cup stage.

The mints usually grown in England, *Mentha villoso-nervata* and *M. spicata*, are highly susceptible to rust, and the aecidal stage often causes much damage to the former in forcing houses in the early spring.

M. cordifolia, a rather coarse species, is highly resistant. It is not suitable for forcing, but is relatively hardy, and shoots can be cut from it during the winter months.

Control

There is no method known which will control satisfactorily the spread of the summer or uredo stage of the rust, but plants entirely free from infection can be produced by warm-water treatment of the runners. This method is especially valuable when the mint is to be forced in glasshouses during the winter.

The warm-water treatment is carried out on the dormant runners when they are lifted from the open ground in the autumn, winter or early spring before they are taken into the glasshouses for forcing. It is effective however badly rusted the shoots may have been when out of doors during the previous summer. Temperatures between 105° and 115°F for ten minutes are all equally good, and cause no damage to the mint.

The water is heated in a copper or bath to about 112°F but not above 115°F. A reliable thermometer should be used. When this temperature is reached, the gas or other jets may be extinguished, if desired, to avoid overheating at the bottom of the bath. A grid placed over the bottom will also help to ensure this. The roots should be well hosed with cold water and

then placed in the bath for ten minutes. If the bath is heated by jets and these have been extinguished, a cover should be put over the bath to conserve the heat during the treatment. If the bath is heated by a fire, the roots should be kept stirred with a stick to keep the water at a uniform temperature. After ten minutes the roots must be removed and hosed down at once with cold water.

Runners treated by this method produce a luxuriant growth of shoots and should therefore be planted wider apart than usual.

Cuttings may be treated similarly at 111°F for ten minutes. They should be loose, not in bundles, and should be cooled down and planted immediately after treatment.

Wilt

Verticillium wilt has been reported on mint. If it appears in forced mint, infection of greenhouse or field soil, or of the stools themselves, might be suspected.

TOMATO

Damping-off and Foot Rot

Damping-off affects the plants in the seedling stage. The young stems are attacked at soil level and fall over, and patches of plants in the seed-boxes may be killed. The most common causes of damping-off in tomato seedlings are the soil fungi *Phytophthora cryptogea* Pethybr. & Laff., *P. parasitica* Dast. and *Corticium solani* (Prill. & Delacr.) Bourd. & Galz. All these fungi also attack the young plants at planting-out time, causing the condition known as foot rot or black leg. The base of the stem is blackened and the plant may collapse or topple over (Plate XI). Recovery sometimes takes place, the diseased area remaining as a constriction round the stem, but plants affected in this way are apt to wilt when the fruits are being formed.The two species of *Phytophthora* cause typical foot rot, while *Corticium solani* causes a wire stem effect, such as in brassica crops, and also attacks the roots.

Control

Where these diseases occur, the seed boxes, pots and propagating soil should always be sterilized with formalin or steam (see p. 83). Steam sterilization is always best; the chemical methods mentioned below are useful but they should be regarded as palliatives to be adopted when steam sterilization is not possible, or for use among growing seedlings after the disease has appeared.

In America treatment of the seeds with cuprous oxide has protected the plants to some extent even in contaminated soils, and watering the soil, after sowing the tomato seeds, with a 1 in 600 formalin solution has also proved beneficial. By removing affected plants from the seed-box and then watering with a cuprous oxide suspension, at the rate of $\frac{1}{2}$ oz per gal, spread of the disease may be checked. Cheshunt compound (p. 89) and proprietary copper compounds, watered on at normal spraying strength, may also be effective. The plants may, however, be injured by too many such applications.

Normally, the seed-boxes are watered before sowing and not again until they appear to need water, without drying out. Watering in the morning is preferable so that the soil surface is dry at night.

If, despite thorough soil sterilization, damping-off and foot rot due to *Phytophthora* still occurs, it is possible that the water supply may be contaminated with the fungi. Such infection may come from ponds, shallow wells or slow-running streams. Wells or tanks should be cleaned out very thoroughly, and if there is evidence of persistent infection a chlorine-water sterilizer may be added to the water at a dilution of 1 to 4,000 by volume.

When *Corticium solani* is involved the treatments suggested for *Corticium* damping-off of lettuce (p. 39) should be tried.

The temperature in the early stages of growth is important, since too low temperatures of air and soil are conducive to seedling disease.* At planting, the soil temperature should be not less than 57°F. Again, injury may be caused after steaming by release of ammonia from soils of high organic content of manganese from acid soils.

Correct flooding before planting and careful watering afterwards will reduce the danger of black leg and root diseases. Too heavy or rapid application of water tends to seal the soil surface and lead to root suffocation. Good crop management* coupled with sound hygiene has much to do with freedom from root troubles generally.

If the plants wilt at a late stage, due perhaps to earlier infection with the foot rot fungi, they may be induced to produce fresh roots by mulching with peat. This should be laid down evenly 1½ in. deep and should then be watered thoroughly and subsequently kept moist.

Root Diseases

Root diseases associated with various fungi, such as *Colletotrichum atramentarium* (Berk. & Br.) Taubenh., *Thielaviopsis basicola* (Berk. & Br.) Ferraris, *Corticium solani* (Prill. & Delacr.) Bourd. & Galz. and *Fusarium* spp., are usually due primarily to faulty drainage or heavy soils, excessive salts content, root damage when potting or planting out, chilling of the roots by planting out at too low soil temperatures, or inadequate flooding of the sub-soil before planting, and are often an indication that the soil is heavily contaminated and should be replaced or sterilized. The plants may wilt during the day, but usually recover a little at night or during dull weather. The root systems are poor and cropping is greatly reduced. In toe rot, caused by *Phytophthora verrucosa* Alcock & Foister, the extremity of the tap root and subsequently the whole root system is destroyed. Powdery scab (*Spongospora subterranea*) of potatoes produces galls on tomato roots resembling root knot (caused by eelworms).

A common cause of root injury, which may be followed by wholesale rotting of the roots induced by some of the fungi referred to, is infestation with the garden symphylid, a small white millepede-like creature. These may be detected by immersing some of the soil in a bucket of water, when the symphylids will float to the surface. For positive diagnosis and treatment an entomologist should be consulted.

Control

Drainage and cultural operations should be improved, as indicated. Insertion of vertical layers of straw may produce a beneficial effect in heavy soils or the physical condition of the soil may be improved by incorporating bulky organics, such as dung, peat, shoddy, etc., especially in the surface

* For information on cultural management, see Bulletin No. 77, *Tomatoes*.

layers. Contaminated soil should be sterilized or replaced with fresh soil (p. 83). If the cause of the trouble is detected early enough, the disease may be largely overcome by top dressing with moist peat about 1½ in. deep. The plants are then encouraged to throw out fresh stem roots. The peat is kept watered until abundant new roots appear, and these should be fed by dressings of fertilizers or well-rotted stable manure. If wilting has been severe it is advisable, when the peat has been applied, to close up the house, shade the glass, and damp the plants overhead frequently until the new root systems become established.

When wilting occurs at a late stage owing to infection of the roots with *Phytophthora* spp. the diseased plants should be removed since the fungus infects new roots as they are formed, and often the plants do not recover. Shoots from neighbouring plants should be trained up in their place.

Verticillium Wilt

Verticillium wilt* (*Verticillium albo-atrum* Reinke & Berth. and *V. dahliae* Kleb.) causes symptoms rather similar to those of root rot. The former disease, however, is severe only when temperatures are low, and under ordinary weather conditions in England ceases about mid-June, often reappearing about the end of September.

Under conditions favourable to infection, such as a temporary check caused by drought, etc., wilting may take place suddenly, the lowest leaves being first affected. Such plants may recover to some extent during the day, but usually wither off eventually from the base upwards. Under conditions less favourable to attack, the plants may be stunted, with short internodes, so that the foliage forms a rosette. Yellow blotches appear on the leaves from the base of the plant upwards and the leaves may wither gradually. A characteristic symptom of verticillium wilt is discoloration of the woody strands or sap-conducting vessels, which appear brown or straw-coloured when the stem is cut open lengthwise. In this disease the discoloration may extend to near the apex of the plant, whereas in root rot it is restricted to near soil level.

The fungus invades the plant through the roots and, entering the vessels, secretes a toxic substance which leads to wilting and eventually to the death of the plant.

In Guernsey a useful diagnostic feature early in the growth of the plants enables growers to discard infected material. When the plants are four to six weeks old the first true leaf formed is yellowish and short in comparison with the succeeding leaves.

Control

When verticillium wilt has been diagnosed the glass should be shaded and the houses closed down more than usual. The plants should be kept on the dry side, but should be damped overhead. Meanwhile the temperature should be raised to 77°F, and if this average temperature should be maintained for about a fortnight, the plants will recover sufficiently to produce a crop, but after any subsequent drastic fall in temperature the plants may show further symptoms. Affected plants may be encouraged to produce new roots by a top dressing of fresh soil or peat. These measures are not effective where the disease is caused by *V. dahliae*.

* See Advisory Leaflet No. 53.

When only a few plants are affected they should be removed carefully and burned, and the holes watered with a solution of copper sulphate (bluestone) at the rate of 1 oz to about 2 gal water. Alternatively, the soil round the diseased and neighbouring apparently healthy plants should be removed or sterilized by means of formalin at the end of the cropping season. If part of a house is slightly infected it may be shaded and the temperature kept high. After a severe attack of verticillium wilt it is necessary to burn all the plants and to sterilize the soil thoroughly by steaming (p. 83). Soil treatment with chloropicrin has also given good results.

Fusarium Wilt

Fusarium wilt caused by *F. oxysporum* f. *lycopersici* (Sacc.) Snyder and Hansen is distinguished from verticillium wilt by frequent one-sided development of wilting and by a dark discoloration of the vessels, which extends into the roots and lower part of the stem. The first symptoms are a clearing of the small veins and drooping of the petioles and yellowing of the lower leaves, often on one side of the plant only. Fusarium wilt is seldom seen in England but occurs in the Channel Islands, being favoured by an optimum soil temperature of about 82°F (28°C).

Control

The sanitary measures suggested under verticillium wilt should be applied. Shading and reduction of temperatures assist greatly in reducing fusarium wilt. In other countries, varieties have been bred for wilt resistance.

Spotted Wilt

Spotted wilt*, a virus disease, is often serious on mixed nurseries where other susceptible plants, especially ornamentals are grown, but is easily controlled when the circumstances of its origin and spread are known.

The first symptoms on the young leaves are a slight clearing of the veins accompanied by pale ring spots. Later a characteristic bronzing appears, either extending over most of the surface of the young leaves or in the form of concentric rings. At the same time, the topmost leaves curl downwards and the growth of the plant is checked. Sometimes, especially if infected at an early stage, the plant may be killed. In more mature plants and possibly at higher temperatures, these symptoms give place to a yellowish mosaic mottling with some leaf distortion. The fruits may show a pale irregular mottling or distinct concentric circles.

There is no evidence that the disease is seed-borne. In England the virus that produces it is transmitted from one plant to another by the common greenhouse thrips, *Thrips tabaci*.

Spotted wilt affects a large number of ornamental plants and weeds, belonging to different families, on which the symptoms are usually either ring spots or bronzing. The most important to the grower are those often found in glasshouses in proximity to tomatoes, especially the perennial plants. Among these are the calla (arum) lily, *Richardia africana*, on which small pale spots are developed on the leaves; chrysanthemums (rare), on which pale ring spots, mottling, bronzing or purpling, and severe "rusting" are produced; and dahlias, on which mottling or ring spots occur. On winter cherry (*Solanum capsicastrum*) the leaves may be covered with yellowish concentric

* See Advisory Leaflet No. 238.

circles. On gloxinia the disease produces very distinct purplish rings, while on *Primula malacoides* and *P. sinensis* the effect is yellowing and stunting, and sometimes the plants will eventually die.

Control

Young tomato plants which have been bought in should be carefully examined, and any with suspicious symptoms should be rejected. Tomatoes should not be grown in mixed houses. If this is unavoidable, ornamental plants showing symptoms of the disease should be rogued out. It is essential in mixed houses not to tolerate the presence of any perennial plants, such as callas, affected with spotted wilt. Diseased tomato plants should be taken up and removed from the houses as quickly as possible. Some of the host plants, such as callas and cinerarias, are specially favoured by thrips and are therefore particularly dangerous. Other plants, not susceptible to the disease, but specially attractive to thrips, are roses and carnations.

Thrips should be kept down either by treatment with DDT, BHC, or malathion smokes, aerosols or sprays. If desired, nicotine as a spray or smoke may be used. Seedlings should be treated with parathion or nicotine smokes.

There appears to be a slight danger that the virus may be carried from plant to plant on the hands of workers and on pruning knives. It is therefore advisable to wash the hands in soapy water after removing and destroying affected plants.

Mosaic

Mosaic* of tomato is caused by the tobacco mosaic virus. The symptoms are well known to growers, the affected plants showing a mottle with raised dark green areas and some distortion of the youngest leaves.

Under high summer temperatures and bright light the mottling may be severe, but otherwise the plants may be little affected. During the winter, however, under poor light and temperature conditions, fern-leaf symptoms and considerable stunting may become apparent. Mosaic infection may cause slight irregularities in the red colour of the fruits, or "mistiness", and the yield may be considerably reduced.

There are several distinct strains of the virus. One of these can cause curious malformations of the leaves, so that the leaflets are greatly reduced in breadth and sometimes end in a corkscrew tendril. In addition, there may be outgrowths or enations from the under surfaces of the leaflets and proliferation of shoots so that the plant appears abnormally bushy.

Another strain causes yellow or aucuba mosaic. The first symptoms are corrugation and downward curling of the young leaves. Pale spots then appear, and subsequently the whole surface of the leaves becomes pale yellow or white, with small islands of dark green. The mature leaves are dark green with irregular angular patches of yellow or white. The growth of the plant is stunted and spindly, while the fruit may be mottled.

A more severe form of the disease, known as streak (Plate XII), usually first becomes apparent when the fruits are beginning to ripen. Dark brown longitudinal stripes appear on the stems which become brittle and easily broken, and when cut lengthwise are seen to be discoloured inside. The leaves also have brown markings extending to both surfaces and may shrivel

* See Advisory Leaflet No. 38.

up. The fruits are often disfigured with rounded or irregular brown blotches. These symptoms are especially liable to appear in houses that have been heavily manured with nitrogenous fertilizers or when plants, grown in high temperatures with excessive moisture, suffer from a deficiency of potash or from sudden drought.

The tobacco mosaic virus is probably carried over in the soil from season to season on small pieces of plant material. It also appears probable that the disease is seed-borne to a slight extent on the surfaces of recently extracted seeds. The virus can be transmitted readily by workers handling the plants and the disease is often rapidly spread in this manner.

Control

Since this virus also attacks tobacco and can be carried in cured smoking tobacco, cigarettes, etc., it is inadvisable for workers to smoke or chew tobacco in the glasshouses. Those in the habit of using tobacco should wash their hands carefully with soap and hot water before starting work. Care should be taken to keep clothing clean since it is liable to become contaminated with infected sap. The pruning of diseased plants and those immediately adjacent to them should be left until all the healthy plants have received attention.

Seed should be saved only from healthy fruits on mosaic-free plants. The seedlings and young plants should be examined and any that appear abnormal should be rejected.

Owing to probable transmission of the disease in the soil, it is advisable, where mosaic has occurred to a serious extent, to burn affected plants and to sterilize the soil with formalin or by steaming. The glasshouses should also be cleansed as described on page 95 and new fillis used for tying.

Any check to the growth of the plants intensifies the virus symptoms. A top dressing of complete fertilizer will often enable the plants to outgrow the disease to some extent. But the aim should always be to obtain the best growing conditions and balanced manuring.

Mixed Virus Streak

Mixed virus streak, which is caused by interaction of the tobacco mosaic virus and potato virus, has been recorded from various parts of England. The source of the second component can sometimes be traced to potatoes growing near or among the tomatoes or being sprouted in the houses. The symptoms are practically identical with those of ordinary (or single-virus) streak, but they may be more severe. The fruits have superficial raised brown markings, whereas in ordinary streak the markings are depressed. Both viruses are transmissible by handling.

Bushy Stunt

Since it was first reported in 1935, the virus disease known as bushy stunt has occurred only very rarely in this country. In young plants the lower leaves become purple, yellow spots appear on the young leaves and there is a general scorched appearance. Such plants may also have brownish streaks on the upper part of the stem and are readily attacked by foot rot or root rot fungi, so that they often wilt and die.

If a plant becomes attacked at a later stage it stops growing and the top leaves show distinct yellow spots or ring-like markings or sometimes only a mild mottle. A profuse growth of stunted secondary shoots is then usually

produced, giving a bushy appearance. The leaves on these shoots may be curled and malformed, with reduction of the leaf-blades, while the top leaves may continue to be normal except for scattered yellow spots or rings. The fruits may be normal, but small and poorly shaped, or have yellow ring and line markings.

Control

Diseased plants should be removed and destroyed, and as the virus is liable to be carried on the pruning knife or on the hands of workers the same precautions should be taken as recommended for tomato mosaic (see p. 69).

Tomato Black Ring

The symptoms of this rare virus disease are most marked on young plants. Small black rings develop on the leaves, accompanied by dark streaks on the petioles and sometimes on the stem. Eventually the leaves and growing point become black and shrivelled and the plant dies. If the young plants survive, however, they grow away normally, except for a slight dark green mottling and slight distortion of the leaves.

The virus also affects several ornamental plants and weeds, which may be carriers.

Aspermy

The virus disease aspermy is not uncommon in some areas on tomatoes grown in proximity to chrysanthemums, usually out of doors, but occasionally under glass. The most conspicuous feature is inhibition of the growing points so that many axillary shoots are produced, giving the plant a bushy appearance. The leaves are rather distorted and mottled with dark green. The fruits may be small and seeds are either absent or few in number.

The virus is widespread on chrysanthemums, on which it causes flower mottling and distortion, and is transmitted by nearly all the species of aphid infesting chrysanthemums. Tomatoes are apparently infected from chrysanthemums, so that care should be taken to keep these crops apart and to control aphids, especially during the early stages of growth.

Cucumber Mosaic

Cucumber mosaic* virus (p. 60) is commonly transmitted by aphids from vegetable marrow to outdoor tomatoes. Leaf mottles of varying intensity are produced on tomatoes, often accompanied by slight narrowing of the leaf blade. In contrast with tomato mosaic, these symptoms arise even under conditions of high light intensity. Cucumber mosaic together with tomato mosaic produces a severe form of streak (p. 70).

Control

Tomatoes should not be grown out of doors in close proximity to vegetable marrows, and the control measures suggested in the case of the latter (p. 63) should be borne in mind. It should be remembered also that the disease affects spinach and celery, though perhaps less commonly, and many ornamental plants and weeds.

* See Advisory Leaflet No. 340.

Leaf Mould

Leaf mould* (*Cladosporium fulvum* Cooke) is a very common and troublesome disease of tomatoes under glass. It usually appears in June or July, but in some districts has been observed as early as April. The first symptoms are yellowish spots on the upper surfaces of the leaves. On the undersides of these spots there is a pale greyish mould consisting of fungal threads and spores which readily spread the disease to other plants (Plate VI). In severe cases the flowers may be attacked. Leaf mould is also found on tomato plants out of doors but is rarely serious.

Control

The disease is favoured by hot and moist conditions and can be kept under control largely by cultural practices. As far as possible the temperature of the houses should not be allowed to rise above 70°F nor the humidity to exceed 70 per cent. At 90 per cent relative humidity spores are produced copiously, but at 70 per cent infection is slight and the disease remains quiescent, while at 58 per cent the fungus growth dries up. In commercial practice high humidities are prevalent at night during May, June and July, and often lead to serious outbreaks. Ample ventilation is therefore of the greatest importance, especially in localities where high humidities are prevalent in the early summer. The glasshouses should be in an open situation. Adequate side ventilation should be secured and, if necessary, ventilators should be inserted at the ends of the house and continuous roof ventilators at each side of the ridge. Extra ventilation may be especially necessary when the houses are on a slope and there are pockets of stagnant air. The ventilators should be opened gradually in the early morning. The object should be to maintain a very slight movement of air continuously throughout the houses. In difficult cases, installation of a fan should be considered. If temperatures tend to rise unduly, a light shading on the glass may be helpful.

Watering should be done judiciously, the plants being kept neither too wet nor too dry. If in spite of all precautions the disease begins to appear, all leaves below the fourth truss should be removed and burned as soon as the fruit from this truss has been picked. At the same time, overhead damping should be avoided, and watering should be done in the morning and on bright days to ensure that the plants are relatively dry during the night. If the weather is very humid, a little heat should be put on to keep the atmosphere buoyant. In difficult localities, some growers keep heat on as far into the season as possible and close down as late as possible in the evening, to encourage air movement.

In houses where leaf mould occurs every year, and where improved management fails to bring satisfactory control, fungicides should be applied as a preventive measure. Thiocarbamate preparations (p. 92) have given good results in the control of leaf mould. Freshly made zineb, prepared by mixing nabam and zinc sulphate, applied at high volume or atomized gives excellent results even under unfavourable conditions. Zineb sprays also give satisfactory results but formulations which do not leave heavy deposits on the fruits should be used; zineb is also available in the form of a dust, to be blown into the air round the plants.

* See Advisory Leaflet No. 263.

Salicylanilide and a wetting agent, is especially useful on tender growth before the end of May. It should be applied at intervals of about a week, either at high volume or atomized.

A number of copper compounds are available and are usually preferred later in the season. When the plants are vigorous, colloidal copper sprays have the advantage that they may be combined with white oil emulsion for the control of red spider mite. These combined sprays should be used after May. In some districts, particularly in the north, certain varieties of tomato such as 'Potentate' are liable to oedema (p. 80) following the application of copper-petroleum sprays, even though precautions are taken. To avoid scorching, also, the colloidal copper white oil emulsion should not be applied within ten days of salicylanilide or sulphur sprays, and the plants should not be watered for three days before or three days after its application. The colloidal copper spray can also be used with other wetting agents.

Phenyl mercury salicylate applied as an aerosol has been widely used, but needs to be used with caution. There are statutory regulations laying down the conditions under which the material can be used and users are strongly advised to read the Ministry's leaflet APS/1 "The Safe Use of Poisonous Chemicals on the Farm" obtainable free from the Ministry of Agriculture, Fisheries and Food (Publications), Ruskin Avenue, Kew, Richmond, Surrey. To avoid the risk of harmful residues occurring on the fruit, official recommendations specify that not more than 5 applications, at not less than weekly intervals, should be applied during the growing season.

The varieties 'Stirling Castle' and 'Up-to-date' are highly resistant to leaf mould, but the quality and yield of fruit is not always satisfactory. In 1936, the Cheshunt Experimental and Research Station distributed the variety 'Leaf Mould Resister No. 1', another highly resistant variety. The variety 'Vetomold', a hybrid between 'Potentate' and the 'Red Currant Tomato' (*Lycopersicon pimpirellifolium*), first received in this country from Ontario, Canada, in 1939, and distributed from Cheshunt, was at first immune. The 'John Innes' and 'Auchincruive' varieties are among others recently introduced. There are, however, at least six races of the fungus in this country. All these varieties are susceptible to at least one of them. The increasing use of F 1 hybrid tomato varieties, however, may accelerate the recombination of resistance genes into new varieties. At present 'Sapsford's No. 1' and 'Antimold B' are resistant to most of the leaf mould races common in this country.

Where there has been a severe epidemic of leaf mould it is advisable to burn all the diseased material at the end of the season. The house may then be sprayed with emulsified cresylic acid, or with a formalin solution (p. 84), and closed up for four days. Alternatively, fumigation of the house with sulphur dioxide, preferably before the plants are removed, has been found to be effective in destroying any hibernating spores. This is done by burning flowers of sulphur. For houses which can be sealed effectively, sulphur should be used at the rate of 4 lb per 10,000 cu. ft. At this rate it will not injure zinc wire or zinc paint if the houses are fairly dry but superstructure and wires should be hosed down afterwards. Where houses cannot be sealed effectively, additional amounts will be required. The sulphur should be distributed in small heaps so as to provide for quick burning and a rapid evolution of gas. A little wood wool placed under each heap will enable the sulphur to be

ignited easily. Where there is much zinc wire or paint the formalin method is to be preferred, to avoid injury.

Blight

Blight* caused by the potato blight fungus *Phytophthora infestans* (Mont.) de Bary, is very common and destructive on tomatoes grown in the open, especially in the south-west, when the rainfall is abundant in late summer and autumn. In some seasons it is found also on tomatoes under glass, especially when potatoes have been attacked by blight outside the houses.

Large russet-brown marbled areas appear on the green fruits (Plate VI), which eventually become completely brown and shrivelled, and, under moist conditions, covered with white fungus threads. The fungus also produces dark brown to black streaks on the stems and, on the leaves, dark brown areas resembling those caused by the disease on potato leaves.

Control

To ensure a satisfactory crop it is essential to protect the plants. Outdoor tomatoes should be sprayed, as a routine measure, with one of the copper fungicides recommended for use against potato blight. Bordeaux mixture 4:4:100 is effective but sometimes causes slight scorching and hardening of the leaves and a visible deposit may be left on the fruits, so that they may have to be wiped. For this reason one of the proprietary copper fungicides is often preferred. Copper lime dust is commonly used where water supplies are inadequate, but in this case more frequent applications are usually required. Zineb, nabam and zinc sulphate and zineb dust are also used.

Spraying, or dusting, should commence not later than the end of July, or sooner if potato blight is seen in the neighbourhood. All fresh growth should be protected by applications made at intervals of about a fortnight. Any diseased leaves and fruits should be picked off and burned.

It is suggested that in commercial plantings the rows should be broken at intervals of 50 yd by alleyways about 9 ft wide. Headlands of similar width should be arranged. The distance between the rows or double rows should be not less than 3 ft. The wide alleys and headlands provide the necessary room for a spray outfit. From the outfit, lengths of hose of about 75 ft are drawn down between the rows. To avoid damaging the plants it is advisable to pass the hose round a crowbar at the entrance to the row. At times it may be possible to use overland mains at the 50 yd intervals when the width of the alley might be reduced.

To obtain satisfactory cover, at least 400 gallons of wash per acre are required. This can be applied by means of a 3-nozzle broom, provided not less than 350 lb per sq. in. of pressure and sufficient volume are available. With this equipment several rows can be sprayed rapidly from one inter-row space. Small machines, either power or manual, can be used if this type of outfit is not available, but the time taken is considerably longer. In small gardens applications by means of a fine-rosed watering can may serve to protect the plants where otherwise the entire crop would be lost.

If the plants are properly spaced, staked and pruned they are less liable to be severely attacked. Potatoes should not be grown in the immediate vicinity of large plantings of outdoor tomatoes or of glasshouses containing

* See Advisory Leaflet No. 271.

tomato plants. The disease can be kept down in glasshouses by raising the temperature and keeping the atmosphere dry. In America, fruits from blighted plants are sometimes dipped for two minutes in a sterilizing wash (1 part commercial formalin to 300 parts of water) and then allowed to stand for four or five days before sorting and packing. This is said to reduce the amount of rot considerably.

Alternaria Blight

Alternaria blight (*Alternaria solani* (Ell. & Mart.) Sor. sensu, Jones & Grout) appeared in south and south-east England in 1944. The symptoms of this disease, known in America as early blight, are rather angular brown to black spots, with target-board markings on the leaves, small sunken dark spots with raised grey centres on the stems, and large flattened lesions at the sepal end of the fruit, which become covered with a velvet-like mass of black fungus.

Loss is caused by premature shrivelling of the leaves, and by fruit rot and fruit drop.

Control

Affected debris should be burned and rotation carried out. Seed should not be saved from affected crops. If the disease becomes prevalent in a district, it is advisable to grow the tomatoes some distance from potatoes, which are also affected. Zineb or nabam plus zinc sulphate is said to be effective in the U.S.A.

The symptoms of autogenous necrosis (p. 81) closely resemble those of alternaria blight.

Stem Rot and Fruit Rot

Stem rot and fruit rot (*Didymella lycopersici* Kleb.) has assumed great importance among glasshouse and outdoor tomatoes in recent years. The most noticeable symptom is sudden wilting of mature plants. When these are examined closely a soft brown or black canker is seen on the stem near soil level. If the canker is examined under a strong lens it may be possible to see the minute pimple-like fruiting bodies of the fungus, which give rise to waxy masses of pinkish or grey spores. *Didymella* lesions are sometimes confused with *Botrytis* lesions. Where there is any doubt, material should be submitted to a specialist, since early control measures for stem rot are important.

The fungus occasionally causes a leaf spot. Tomato fruits are severely damaged, especially those grown in the open, by infection with *Didymella* towards the end of the season. A circular black area appears at the stem end beneath the calyx and the fruit becomes completely black and rotten (Plate V).

Sources of infection are contaminated soil, canes, woodwork, etc., and seeds affected with the fungus. The seedlings become infected and may damp off, especially when crowded and kept rather damp. Slightly affected seedlings develop the typical cankers or affected roots later on. Infection may also be carried on stakes, seed-boxes and plant remains, or anything with which diseased plants have come in contact. During the growing season, spores of the fungus are distributed by watering, rain, cultural operations, tools, the

hands and clothes of workers, etc., and bring about secondary infections on fruits and on stems, especially where they are wounded. In winter, spores may be carried into empty greenhouses from infected fruit outside.

Control

Seed should be saved from healthy fruits grown in a glasshouse or bought from a reliable source. Only healthy seedlings should be used for transplanting.

If stem rot develops under glass the diseased plants should be removed immediately, along with some of the surrounding soil, and burned. Care should be taken to avoid wounding the stem in training, while clean cuts should be made in pruning, close against the stem. Painting stem rot lesions with creosote or a captan paste may help to prevent spread of spores.

At the end of the season the diseased plants in badly affected glasshouses should be cut off about a foot from the ground and sulphur burned in the houses as described on p. 73. The haulms and strings should then be removed and burned, and the soil, seed-boxes and pots sterilized effectively. New or sterilized twine should be used in the following year. Since spores may be distributed by watering, this should be done carefully in the neighbourhood of diseased plants. Trickle irrigation or the use of pots may help to avoid stem rot.

Preparations of dithiocarbamates have been found to be fairly effective as eradicants and protectants, while captan appears to be valuable as a protectant. In outdoor plantings, the affected plants should be removed and the bases of the stems of adjacent ones painted or sprayed with 1½ per cent maneb (note that in some cases this may injure young plants and an excess of the fluid should not be allowed to reach the roots). The stem bases of those more distant should be sprayed with 0·5 per cent captan. In plantings in glasshouses where *Didymella* has appeared in previous years, the lower part of the stems of the young plants and surrounding soil should be sprayed with 0·5 per cent captan, one or two days before planting out, and again three weeks afterwards.

With outdoor crops the plants should be cleared and burned, and the canes should be dipped in 2 per cent formalin for 24 hours or in 5 per cent for 15 min, and then wrapped in sacks for one week, to allow the fumes to continue to act. As long a rotation as possible should be adopted: an interval of at least two years is necessary.

The final picking at the end of the season for artificial ripening should be completed before the weather becomes cold and damp. Fruits in different stages of maturity and different varieties of fruit should preferably be kept apart.

The fruits, which should be picked with the calyx attached, are placed on a 6-in. layer of clean straw on the floor of a glasshouse (preferably not one used for indoor tomato growing, to avoid the risk of contaminating the house) or a well-built shed. Where space is available trays may be used. The fruits should be protected from bright sunlight. If necessary they should be covered with a light canvas material. The building should be kept at an even temperature of between 60° and 65° F. Diseased fruit should be removed daily and destroyed. As soon as the fruits begin to colour they should be removed and packed into chips ready for market.

Bacterial Canker

Bacterial canker (*Corynebacterium michiganense* (E. F. Sm.) Jensen). This bacterial disease was introduced into England with imported seed in 1942; it caused concern for a time but it is now uncommon.

Symptoms on outdoor crops are marginal browning, curling and withering of the lower leaves, with withering of the leaflets on one side only of the leaf-stalk, on which there may be dark streaks. When the leaves of a diseased plant are cut off flush with the stem, yellow or brown dots in the form of a horse-shoe can be seen.

If the middle or upper part of the stem is cut lengthwise, a yellow, light brown, or dark brown streak can be seen just inside the woody cylinder.

When infected fruit is cut open, yellow or brown marks can be observed which run inwards from the stalk to the placenta; bacteria ooze from these when the fruit is gently squeezed.

Control

The disease is seed-borne and spreads from plant to plant in the seed-boxes and, later, when pruning takes place. It may be carried over in the soil and in compost from year to year.

Seed should not be saved from plantings where the disease has occurred, and contaminated soil in glasshouses should be steam-sterilized. Infected plants should be burned together with the string, etc., used for supporting the plants. Stakes should be sterilized. Tomatoes should not be grown the following year on infected land out of doors.

Tomato growers are advised to keep a watch on their plants, and, if bacterial canker is suspected to report the matter at once to their local Horticultural Officer or Advisory Plant Pathologist.

Soft Rot

A malodorous soft rot (*Pectobacterium carotovorum* (L. R. Jones) Waldee and other bacteria) of tomato stems may be confused with bacterial canker, and indeed may sometimes follow it. The pith becomes yellow brown and entirely disorganized and the outsides of the lower parts of the stems discoloured and slimy. When the leaves are cut off flush with the stem the pith is seen to be disorganized but the horse-shoe markings of bacterial canker are lacking. The disease is usually associated with over-nitrogenous, unbalanced nutrition, or with the use of stable manure.

Brown Pith Necrosis

A brown dry necrosis of the pith, which finally results in hollowness of the pith of stem and petioles, has been noticed several times in recent years. Invasion of the cortex with formation of black lesions often occurs. A soft rotting *Pseudomonas* sp. is sometimes associated with the trouble, though it is not yet certain whether this is a primary cause.

Grey Mould and Water Spot

Grey mould and water spot (*Botrytis cinerea* Fr.) is often found towards the end of the season in unheated or neglected houses, or where tomatoes have grown with other plants, such as lettuces (p. 35) which are liable to be attacked by this fungus. The fungus infects the stems at pruning wounds,

leaf scars, etc., causing them to rot, and they soon become covered with the characteristic powdery grey or brownish mould growth. In very moist weather or in close, over-watered houses, the fungus may attack the flowers, causing them to wither prematurely.

Water spot of the fruits is also due to *Botrytis* infection. The water spot marks are usually found on the upper half of the fruits and develop while the latter are still green and immature. Each mark consists of a minute raised brown spot, surrounded by a circular zone of normal colour which in turn is surrounded by a zone of very pale green. The size of the spots on unripe fruits varies from $\frac{1}{32}$ to $\frac{1}{8}$ in., and rarely exceeds $\frac{1}{4}$ in. on the ripe fruit. Occasionally, infected fruits may decay with a soft rot.

Water spot is produced under conditions of high humidity, such as occur during the night, when small drops of water are formed on the surface of the fruit. *Botrytis* spores germinate in these drops and secrete an enzyme which diffuses outwards, and produces the characteristic ring. The drying of the fruits during the day usually kills the fungus and so limits its activity.

Fruits are often affected at the sepal end by *Botrytis* and fall off readily. The tissues become soft and watery and the surface is pale grey to white in colour. The fungus is often seen on the surface.

Control

The control of *Botrytis* is largely a matter of employing the best horticultural practice. Adequate ventilation is of the first importance. The atmosphere should be as dry as possible before ventilation is reduced at night. Where improved ventilation is insufficient to prevent sweating, as much foliage as possible should be removed and, if necessary, heating of the houses should be restarted. Any overhead damping, to assist the fruit to set, should be done in the morning, or when atmospheric conditions permit of rapid drying.

All decaying plant material should be removed from the houses, and where the mould has been troublesome it is advisable to cleanse the houses thoroughly with cresylic acid or formalin after removal of the crop (p. 85).

To prevent stem infection with *Botrytis*, side shoots should be rubbed out at an early stage. If the lower leaves are removed later they should be pruned off level with the stem. Any infected pieces of stem should be trimmed off level with the stem and the wounds painted with a paste of liver of sulphur or of tecnazene, salicylanilide, or captan (see p. 88). Creosote painted carefully over the *Botrytis* lesions has been found to dry them up effectively.

Tecnazene dusted on by the cloud method till the first truss sets, with subsequent light dustings, especially after leaf trimming is claimed to bring about some control, but to avoid deposits on the fruit the dust should not be directed at ripening trusses. If a power blower is used little deposit on the fruits may be visible. Thiram, applied to the stem bases at 1 lb wettable powder per 100 gal or at low volume, is also stated to be useful.

If spent hops are used as a top dressing they should be well incorporated with the surface layers of soil, otherwise *Botrytis* is liable to develop on them.

Sclerotinia Disease

Sclerotinia disease (*Sclerotinia sclerotiorum* (Lib.) de Bary) (p. 37) is occasionally seen on tomatoes in glasshouses. The stem is discoloured, brown and brittle

with large black sclerotia developing inside. Infection probably comes from spores blown into the glasshouse, since the fungus is common on weeds.

Buck-Eye Rot

Buck-Eye rot (*Phytophthora parasitica* Dast.) is caused by one of the fungi concerned in damping-off and foot rot. The fungus is a soil inhabitant and infects the fruits of the lower trusses in the early part of the year, the symptoms being grey to reddish-brown patches with darker brown concentric rings.

Control

Where the rot is common, the ground should be mulched with straw, adequate ventilation given and watering slightly reduced. Spraying the soil and the lower parts of the plants with a copper spray has also been recommended.

The diseased fruits should be removed promptly and burned, and the lower leaves trimmed to keep the fruits dry. Careful watering so as not to splash the fruits with water also helps to prevent infection. The lower trusses should be tied up to keep them off the ground.

Blotchy Ripening

This trouble becomes most severe when high temperatures occur either in the glasshouse generally, or locally in the fruit or parts of the fruit, during development and ripening. The fruit may, however, prove susceptible or resistant to the effects of high temperature, depending upon whether the growth of the plants is soft and ill balanced, i.e., low in dry matter or relatively hard and well balanced, i.e., high in dry matter. The former type of plant is induced by growing the crop too fast especially under poor light and by applying water too liberally. The latter factor appears to operate with particular force when soil nutrients, especially potash and nitrogen are at inadequate levels.

Conversely, growing the crop at an adequate level of nutrition, avoidance of over watering and of over rapid growth will promote freedom from blotchy fruit. Adequate and early ventilation during hot weather will also assist in minimising the development of blotchy fruit as a result of high temperatures. Some varieties are more prone than others to blotchy ripening. Storage of the fruit at 60°F for a few days may result in better colouring.

Infection with tomato mosaic may also result in fruit discoloration and necrosis.

Bronzing

In this trouble the symptoms are apparent on the green fruit, unlike blotchy ripening, which it resembles when the fruits are ripe. In slight attacks the fruit appears discoloured, a light brown colour showing through the skin of the green fruit. The bronzed appearance is caused by a necrosis of the cells around the vessels. In severe attacks there are irregular, brownish, slightly sunken marks on the surface, which on cutting show the same browning of the tissues just below the skin.

The disorder is usually associated with soft unbalanced growth, periods of high day temperatures and low night temperatures (59°C or lower) during the spring months, high rates of watering, and low nutrients.

Similar symptoms can be produced by infection with tomato mosaic at a critical stage of fruit formation, bringing about "shock symptoms". The plants may become more tolerant of this infection later on if nutrition is favourable, and later fruits are usually normal.

Sun Scald

The fruits of some commercial varieties are liable to a scorch which is probably a sun scald. The affected fruits show, in the green stage, irregular brown areas on the side most exposed to the sun. On the ripe fruits the markings may be pinkish and more reminiscent of typical sun scald on gooseberries, etc.

Hollow Fruits or Puffiness

Hollowness or puffiness of the fruits is found especially on plants subjected to root injury or with luxuriant foliage. A similar condition may be brought about by interference with pollination (as by high or low temperatures, excess moisture or drought). In this case the central part of the fruits containing the seeds is not fully developed. Cutting down nitrogen to encourage a more balanced growth will help matters.

Watery or Glassy Fruits

The fruits which are not so firm as they should be have a watery appearance, so that the veins become visible. This condition is supposed to be associated with excess of nitrogen, and applications of potash and/or phosphate may be tried experimentally.

Green Back

Frequently the stalk end of the fruit does not colour normally but remains green. The trouble may be attributed to high glasshouse temperatures, to exposure to strong sunlight, or to shortage of potash. It can usually be prevented or minimised by leaving sufficient foliage to shade the fruits, by ensuring an adequate supply of potash and by early and adequate ventilation. Varieties resistant to green back may be available soon.

Blossom End Rot

This is a physiological trouble due to a check in the plant's water supply, caused by drought, irregular watering and excessive levels of nutrient or other salts in the soil, especially where calcium is low. Externally the symptoms appear as a dark green circular patch at the exposed end of the fruit. Later this patch becomes brown or black, shrunken and flattened and leathery in texture. The remedy is to keep the soil uniformly moist especially after feeding with soluble fertilizers.

Oedema or Dropsy

Greyish-white furry blisters or ridges appear on the under surface of the leaves, on the leaf stalks, truss stalks and sometimes on the main stem. The trouble is induced when the water uptake by the roots is in excess of the amount that the leaves can eliminate in the usual way by transpiration. This occurs when the soil is warm and very moist, and the ventilation and light inadequate.

The application of oil emulsion to control red spider mite also reduces transpiration and when these emulsions are used the soil should be kept relatively dry, overhead damping stopped, and adequate ventilation be given for three days after spraying in order to prevent oedema appearing.

Autogenous Necrosis

Autogenous necrosis appears in F1 tomato hybrids, especially when 'Vetomold' is one of the parents, and is due to a combination of certain genes in a proportion of these hybrids. It is accentuated by hot sunny weather. For instance, in the summer of 1957 it was prevalent on 'Syston Cross'. Leaf symptoms first appear as spots or areas which become necrotic in the centre and eventually develop concentric rings resembling alternaria blight. In severe cases, there may be complete shrivelling and drying up of affected foliage, with consequent reduction in yield.

Rogues

"Rogues," "jacks," or "featherlegs" occur in many varieties of tomatoes. They are recognized in the seedling stage by their stocky growth, short internodes, many side-shoots and leafy appearance. As their growth is poor and they develop very little fruit on the first two trusses they should be discarded, as should half-rogues which are intermediate between rogues and normal plants. Seed should not be saved from these abnormal plants and an additional precaution would be not to save seed from the lower trusses of any plant.

Leaf Scorch

Scorching of the leaves of tomato plants can be brought about by fumes from woodwork painted with creosote, from leaky boiler flues or car exhausts in an adjacent garage, from the use of fresh anthracite ashes in proximity to the plants, or by ammonia from mulches of fresh stable manure or from steamed soil of high organic content.

Hormone Weed-Killer Injury

Traces of hormone weed-killers containing 2, 4-D produce severe injury rather similar to that caused by cucumber mosaic. The leaflets become very narrow and distorted and the veins show up prominently and run almost parallel to the mid-rib. The fruits are elongated, beaked and hollow. Affected plants do not usually recover.

Chlorate Weed-Killer Injury

The symptoms rather resemble those of tomato mosaic but the veins stand out prominently. In severe cases, there may be curling and scorching.

Such damage is not uncommon in glasshouses when chlorate weed-killer has been used on paths outside the houses or on the standing-out ground or in the neighbourhood of pots or boxes.

Soaking soil, pots or boxes with a 1 in 40 solution of lime sulphur has been found to reduce most of the chlorate.

Somewhat similar, but less well-defined, symptoms, may be caused by phenolic compounds.

Blossom Drop

Yellowing of the flower stalk at the joint just below the flower, and subsequent dropping of the flowers, is usually an indication that the plants are not receiving sufficient water.

Dry Set

Dry set, in which the fruits remain very small and do not swell further arises directly from failure of pollination. The latter can usually be corrected by spraying the plants lightly with water as soon as the flowers begin to open. Too wet conditions, however, may lead to similar failures owing to infection of the flowers with *Botrytis* (p. 77). Insufficient pollination may give rise to irregularly shaped fruits, or small fruits without seeds.

Magnesium Deficiency

Magnesium deficiency symptoms are often seen on tomatoes in commercial glasshouses. A bright yellow colour appears at the edges of the older leaves and spreads between the veins. This coloration progresses rapidly to the younger leaves. There is usually a serious withering, beginning at the base of the plant and working upwards. In severe cases the fruits show pronounced "green back" with a hard yellow or orange area at the stalk end of the mature fruit.

Control

Magnesium deficiency is liable to appear in glasshouses where the potassium content is high, consequent on heavy applications of potash for many years. In such cases potash manures should be temporarily reduced. In severe cases, magnesium sulphate (calcined Kieserite 30 per cent MgO) incorporated at the rate of about one ton per acre with the basal fertilizer has given a considerable degree of control. A 2 per cent solution of magnesium sulphate has been found to be effective and economical if included in the salicylanilide spray (1 fl. oz per gal) with the addition of a spreader. In severe cases five sprays should be applied, preferably on sunny days, at intervals of about a fortnight during the season.

Potassium Deficiency

Potassium deficiency induces a bluish-green colour of the leaves. The lower leaves develop a greyish colour around their margins and later between the veins. These areas eventually become scorched and brown and the margins curl upwards. The fruits ripen unevenly, giving a blotchy appearance and the flavour is sub-acid and insipid (see Blotchy Ripening, p. 79).

Control

Details of the principles of the potash manuring of tomatoes are given in the Ministry's Bulletin No. 77, *Tomatoes*.

RHUBARB

Crown Rot

Crown rot (*Pectobacterium rhapontici* (Millard) Patel & Kulkarni) is common in the rhubarb-growing areas of Yorkshire and has also been recorded from

other parts of the country. The chief feature is a rotting of the terminal bud. This is accompanied by a soft chocolate-coloured rotting of the pith, often with the formation of a cavity. Spindly side-shoots may then grow out, but the young leaves often rot off. If the weather is wet, the bases of older leaves may become affected. During the summer the diseased plants may be recognized by their puce-coloured leaves.

Infection appears to follow wounds and the eelworm *Ditylenchus dipsaci* (Kühn) is probably frequently involved in transference of the disease from plant to plant. Infection is commonly spread by means of diseased roots removed from forcing sheds, by ploughing in rhubarb refuse and by the use of old infected roots for sets and for manure.

Control

Infected plants cannot be cured, and remedial measures should therefore be concentrated on eradicating the disease. Infected plants should be burned and the ground used if possible for other kinds of crops.

Grey Mould

Grey mould (*Botrytis cinerea* Fr.) is a common trouble in forcing sheds. It can be kept in check by adequate ventilation.

Rhubarb Viruses

There are at least two viruses in rhubarb, associated with ringspots and yellow flecks respectively. Sap transmissions to test plants indicate that the first virus is similar to, and possibly the same as cabbage black ringspot virus. Little is known about their spread, or their effects upon yield.

Control Measures

SOIL STERILIZATION

Soil sterilization is not usually practicable in the open ground since the cost is excessive and recontamination takes place so easily. In the greenhouse it is frequently practised to rid the soil of disease organisms and to promote fertility.

Steam Sterilization

Steam sterilization, the most effective measure, is discussed in the Ministry's Advisory Leaflet No. 319, *Soil Sterilization*, and in Bulletin No. 22, *Soil Sterilization*. The whole of the soil in the greenhouse may be sterilized *in situ* by means of pipes, trays, grids or spikes connected with a steam boiler. The success of the system depends upon obtaining a uniform temperature of 210–212°F in every part of the soil, and in maintaining this temperature for a sufficient length of time to destroy such fungi and pests, etc., as the soil may contain, i.e., about 30 minutes.

The steaming of greenhouse soil has the effect of liberating nitrogen and this upsets the potassium/nitrogen balance. When tomatoes are grown in such

soil it is usual, therefore, to add ½ 1 ton sulphate of potash per acre, applied 14 days before planting. Later, top dressings of sulphate of potash may be necessary if the growth of the plants becomes too sappy and luxuriant.

It is usual to flood the soil with water after steaming. Dirty water will readily contaminate the steamed soil, therefore water from surface tanks should not be used. Care should be taken not to re-infect steamed soil by wheelbarrows, boots, etc.

Small quantities of soil can be sterilized in specially constructed metal boxes through which steam is passed either through a grid of perforated pipes laid on the bottom or through a perforated false bottom. These also are described in the leaflet. If the steam is under pressure, the sterilization can be accomplished much more quickly. If the soil is to be used for vegetable seedlings to be raised under glass, it is sufficient to raise its temperature to 180°F and to keep it at that temperature for 10 minutes. The soil should be heated up as quickly as possible, and it should be removed immediately after completion of the process and spread out in a thin layer in order to cool quickly. The effect of such steaming upon loam is to eliminate most of the disease organisms and to liberate nitrogen in a form available to the plant*.

If injurious effects are to be avoided it is most important to take certain precautions. A reliable thermometer should be used. With composts, the loam and leaf mould should be sterilized separately. No lime should be added before steaming. After the ingredients have been mixed, a small amount of superphosphate (about 1½ oz per bus.) should be added to the compost.

Sterilized soil or composts should preferably be handled with sterilized tools and should be stored on a stone floor which has been thoroughly washed or wiped down with formalin. It is important to realize that sterilized soil may become rapidly invaded by disease organisms if it comes in contact with contaminated soil.

Soil can also be sterilized by baking, but this method is not recommended except for strong growing plants. Baked soil is liable to impede germination of seeds and to injure seedlings. The addition of a few inches of water to the bottom of a baking apparatus may, however, enable it to give fairly satisfactory results. It is advisable to store baked soil for six weeks before use; otherwise the growth of the plants may be retarded. If this is not possible it should be soaked several times with water.

Electrical soil sterilizers are also on sale, and offer a clean and easy method of treatment where the price of current is low.

Sterilization with Formalin

Commercial formalin is a 40 per cent solution of formaldehyde. For the purpose of sterilization, one part formalin is added to 49 parts water, i.e., 1 pt to about 6 gal water. The soil to be treated is spread out on a stone or cement floor in an open shed and the formalin solution is watered on at the rate of 1 gal per bus. of soil. Layers of soil 1 ft deep may be successively sterilized in this way, one above another. The heap is then covered over with sacks for about 48 hours to retain the volatile gas, after which the soil is spread out thinly to dry. It should not be used until all smell of formaldehyde has disappeared.

* The construction of a low-pressure steam sterilizer is described in *The John Innes Sterilizer*, in a collected edition of the J. I. Leaflets entitled *The Fruit and the Soil*, published by the John Innes Institute, Bayfordbury, Hertford, price 3*s*. 6*d*.

When stable manure is suspected of carrying disease it is best sterilized by means of formalin.

The soil in greenhouses and frames can also be surface-sterilized by formalin in the same way. Anything from 2 to 5 gal or more of the dilute solution are required per sq. yd, according to the texture of the soil. In greenhouses, the ground should be dug one spit deep during the same day.

Sterilization with Cresylic Acid

Cresylic acid (mixed cresols) is inferior to formalin as a fungicide, having poor powers of penetration. It is sold as a 97–99 per cent solution (pale straw-coloured) and is diluted before use by adding 1 gal to 39 gal water. This is applied at the rate of 1 gal solution to 1 bus. soil. The soil is covered over with sacks, etc., for 48 hours and then spread out to dry; it can be used after about three weeks. As the acid is corrosive, containers, etc., must be handled with rubber gloves.

In sterilizing soil in glasshouses, the diluted cresylic acid is applied at the rate of 2–4 gal per sq. yd, and is at once dug into the ground so as to leave the saturated layer of soil a foot below the surface.

Planting out should not be attempted until about three weeks after treatment. A few plants may then be placed in the house overnight with the ventilators closed. If these plants are undamaged by the morning, planting out can be undertaken.

Sterilization with Metham-sodium

Metham-sodium (*sodium methyldithiocarbamate*) achieved some success as a soil sterilant in the U.S.A. and is now being used in this country. It is active against soil fungi, soil insects, eelworms and weeds, and likely to prove useful both under glass and in the open. It is sold under several proprietary names, as a concentrated solution in water. When this solution is diluted, and especially when in contact with soil, the metham-sodium breaks down to yield a vapour. This vapour is very injurious to plants and precautions must be taken to prevent it entering glasshouses containing plants, either by seepage through dividing partitions or from house to house via ventilators.

Metham-sodium is usually applied to the soil as a drench, using 2 pt in 25 gal water per 100 sq. ft, but can be injected as with chloropicrin.

It is essential that the vapour is completely released from the soil before plants are brought into the treated houses, and as the rate of release is largely governed by the soil temperature, the treatment should be carried out before the end of October. Optimum soil temperatures at 4 in. depth are 55°–60°C. The soil should preferably be winter flooded before treatment and approach a potting compost condition for moisture at the time of treatment.

Planting up should be deferred until all the vapour has disappeared. In cold soils at least 12 weeks may be necessary. The disappearance of the vapour is hastened by roughly forking over the treated borders once or twice, commencing three weeks after application. The manufacturer's instructions should be very carefully observed.

As tomatoes are extremely sensitive to the vapour the best indication of safety for planting is absence of damage to young tomato plants placed in the house, with heat on, for two weeks before planting.

Protective clothing should be worn during application and a respirator if discomfort to the eyes is noticed. If the concentrate comes in contact with the skin it should be washed off immediately, otherwise blisters may result. In using metham-sodium, care should be taken not to contaminate ponds or streams, and containers should be stored in a safe place away from foodstuffs, and washed out and disposed of safely.

Sterilization with Chloropicrin

Chloropicrin (Trichlornitromethane), the "tear gas" of the first world war, is now marketed for soil sterilization, but its application should be left to a contractor. It is a heavy, volatile liquid which vaporizes in the soil, penetrating 8–10 in. in all directions. It is toxic to insects, fungi and bacteria. Since its effects on man are unpleasant and dangerous, full protective clothing and a gas mask should be worn.

The container should be opened outside, so that fumes are blown away from the operator. The chloropicrin is usually applied by means of a mechanical or hand injector into holes 9–12 in. apart and 4–6 in. deep at 2 to 4 c.c. per injection, depending on the type of soil. Soil temperatures should be at 55–60°F or over at the time of treatment.

As each section of the house is treated, the top ½ in. of the soil is wetted to seal in the chemical. After treatment the house should be shut up, all vents being closed and the doors locked. The gases take 5 to 20 days to escape from the soil and are toxic to plants. Some six weeks are required before planting, perhaps more on the heavier soils.

SEED TREATMENT

One of the objects of seed treatment is to protect seeds from those fungi and other organisms that are commonly present in soil and are capable of causing the seeds or young seedlings to rot before they emerge above ground. Such rotting is known as pre-emergence damping-off, and the fungicides used for preventing it may be called seed protectants.

Seed disinfectants kill disease organisms on the surface of the seeds and sometimes penetrate sufficiently to kill organisms inside the seed tissues.

Dry seed dressings or dusts, some of which are mentioned below, are simply shaken up with the seeds until the latter are coated evenly. The usual rate for peas is about 2 to 2½ oz of the dressing per bushel of seed, but the manufacturers' instructions should be followed closely. Large seeds such as peas and beans may be placed with the required amount of dressing in a specially constructed mixer or in an old churn provided with baffle boards. This is filled about half-full, closed tightly and rotated for several minutes. When large amounts of seeds are treated it is advisable to wear a mask to avoid inhaling the dust. For small seeds a weighed amount of the dust may be shaken with the seeds in a closed tin, or a pinch shaken up with a small paper packet of seeds until they are coated uniformly.

When the seeds are sown out of doors the dressings are most valuable for late autumn or early spring sowings while the soil is cold and wet; little advantage is gained by treating seeds to be sown after April. Injury may result when treated seeds are sown at high summer temperatures or in dry soils. It is questionable whether the use of protective seed dressings on the smaller vegetable seeds is worth while, unless the seed is scarce or expensive.

Organo-Mercury Seed Dressings

Compounds of mercury attached to a complex organic radicle are sold under various proprietary names. Good results have been obtained by treating some varieties of peas with them (at 4 oz per cwt). Precautions to be observed are given under Pre-emergence Damping-off, p. 58. Treatment of the following seeds with organo-mercury dusts has also given improved stands: dwarf bean, tomato, brassica crops and beet. Organo-mercury dusts can be definitely injurious to seeds of lettuce and onion. In addition to their protectant action, these dusts have a disinfectant action. They are poisonous, and precautions (stated on the container) are necessary during their use and storage. With peas it is preferable to use thiram and captan, which give better results and obviate the risks involved in handling treated and harvested seed in the same warehouse.

Suppliers of pea seed will usually carry out seed treatments for a small fee.

Cuprous Oxide

Cuprous oxide (red or yellow oxide of copper) is a seed dressing which attracted attention some years ago in America and has been used in England. It is employed at the rate of about 2½ oz per bus. (¼ per cent by weight) for peas and other large seeds. For peas which are to be sown by means of a drilling machine, 1 oz of 325-mesh graphite must be added per bushel to prevent undue friction and clogging of the drills. For small seeds the rate is 1½ teaspoonfuls per lb of seed (2½ per cent by weight), or a pinch on the point of a knife per packet of seeds.

Cuprous oxide is valuable as a seed protectant for early peas but it is capable of causing injury to some varieties or when the seeds are sown in very dry soils (see p. 58). It has given good results with tomato and cucumber seeds and to some extent prevents damping-off of the seedlings. It has also given improved stands with lettuce. It is injurious to all kinds of brassica seeds.

Zinc Oxide

Zinc oxide is a relatively mild seed protectant. It can be purchased from any chemist, but as fine a form as possible should be obtained. It is used at the rate of 1½ to 2 per cent by weight, which is about 2 teaspoonfuls per pound of seed, or a pinch per small packet of seed. The seeds should be shaken till they become white.

Zinc oxide has given improved stands when used on the seeds of lettuce, tomato, brassicas, onion, carrot and parsnip.

Thiram

Thiram (tetramethylthiuramdisulphide) an organic sulphur originally used for the vulcanization of rubber, is the chief component of seed dressings sold under various proprietary names in England and America. It is neutral, non-corrosive, non-volatile and non-poisonous, but rather irritating in the dry state and may cause dermatitis. It should be used with caution. It is a generally safe seed protectant. At the rate of 4 oz per cwt of a 50 per cent formulation it is stated to increase stands of peas satisfactorily and to be effective for both round and wrinkled peas. Good results have also been

obtained with beets, brassicas, carrots, cucumbers, marrows and spinach. Usually the maximum possible dressing (i.e., that which will adhere to the seed readily after shaking) is not harmful; it is said, however, to be toxic to celery seeds, and occasionally to lettuce under warm and dry conditions. Thiram is also used for pelleting onion seeds against smut (see p. 29).

Captan

Captan (trichloromethylthiotetrahydrophthalimide) now largely used for fruit spraying, has been compounded as a seed dressing (75 per cent captan and is said to have given good results on vegetable seeds generally. On peas (at 2½ oz per cwt) it is as effective as thiram and is relatively safe, but has an unpleasant sickly smell. There are no adverse effects on seed which has to be kept over to the following season. Treated seed of other vegetables, but not tomatoes, can be stored successfully.

Dual-Purpose Seed Dressings

Both the organo-mercury and thiram seed dressings have been compounded with the insecticides BHC, aldrin and dieldrin to produce dusts which protect the seeds against fungi and insect pests, especially wireworms. Excess of BHC is injurious to beet seeds.

Hot-Water Treatment of Seeds

In the case of fungi which penetrate into the seed and are not affected by seed dressings, a hot-water treatment is used. This is fully described in the Ministry's leaflet "Hot-water Treatment of Celery and Broccoli Seed". For large quantities, specially manufactured warm water baths may be used, but for small quantities a simple container, such as a dust bin, open at the top and supported on bricks over a source of heat, would be suitable. A small but steady flame from a gas burner is adequate. Two long accurate "works tested" thermometers inserted in corks floating in the water are required.

The seeds are placed in bags of loosely woven material, which are filled only half to three-quarters full with not more than 5 lb seed a bag.

Slightly warm water is placed in the bath and heated up slowly by means of the gas jet.

When, with constant stirring, the temperature reaches 123°F, the bags of seed are lowered into the water, which should be maintained at 122°F for 25 min. To ensure even heating the bags should be agitated constantly.

At the end of the 25 min. the seed is spread thinly on newspapers and stirred occasionally. The drying process may take about a week. The seed is then rebagged.

The hot-water treatment may reduce germination slightly, not more than 5 per cent in fresh seed. Germination can be tested by spreading 200 seeds on moist blotting or filter paper in a small covered dish, and keeping this at room temperature for 10 days for broccoli and 21 days for celery. Counts of germinated seed can then be made easily. Hot-water treatment does not affect the longevity of the seed and it is best to treat it in the harvest year.

CONTROL OF DAMPING-OFF

Damping-off is a very common trouble and is thought worthy of special mention here, although it has also been referred to under the diseases of

particular plants. Damping-off is caused by fungi occurring in the soil and the first essential is to see that the soil or compost is uncontaminated. This can be done by sterilizing the soil by one of the methods already described. Another method that has given good results with tomatoes is to treat the soil with a preparation made by adding 15 parts of commercial formalin (40 per cent) to 85 parts of sawdust, charcoal or air-dried soil immediately before sowing the seed. Only about 4 to 5 parts of the preparation are required per 1,000 parts of soil to be treated. Several days should be allowed to elapse before pricking out seedlings into soil so treated.

Damping-off fungi are, however, sometimes introduced into the water supply, so that if continued trouble is experienced when sterilized soil is used, the water supply and other possible sources of contamination, such as unsterilized tools, should be considered.

Even though the soil or the ingredients of the compost are not sterilized little trouble may be experienced from damping-off if the following precautions are taken. The pots and crocks should be scrubbed thoroughly and put into cold water, which is then boiled for a few minutes. Pots and boxes may be dipped in a 2 per cent formalin solution. After sowing, the boxes should be watered but should not receive any further water until they require it.

Treatment of the seeds with protectant dressings (p. 86) will prevent them from rotting in the soil, and may often reduce the amount of subsequent damping-off. Too thick sowing and a cold atmosphere are conducive to damping-off and should be avoided.

If the trouble appears, it can usually be checked by watering the diseased seedlings and those immediately surrounding them with a suspension of cuprous oxide in water, at the rate of about ½ oz per gal, but this material should not be used on brassicas. Alternatively, Cheshunt compound can be used. This can either be purchased ready mixed or prepared by grinding together 2 oz finely ground copper sulphate with 11 oz of ammonium carbonate. The mixture is stored in a tightly corked glass or stone jar for at least 24 hours, and the solution prepared by dissolving 1 oz in a little hot water and adding water to make up to 2 gal. The solution must not be put into metal vessels, but a well-painted can is satisfactory. The solution is watered around the diseased seedlings and the neighbouring healthy ones in the same way as cuprous oxide. Proprietary copper compounds, watered on at normal spraying strength, are also sometimes useful.

Damping-off which cannot be controlled by the above methods may be caused by the fungus *Corticium solani* or *Botrytis*. In this case a proprietary compound containing tecnazene (in dust form) may be tried, or thiram or captan applied at 1 tablespoonful per gal of water (at up to 1 pt per sq. ft) watered on to the affected area after the diseased seedlings have been removed.

COPPER FUNGICIDES

There are a number of fungicides available, and different ones are of value for controlling different diseases. These are indicated under the headings of the diseases themselves. Many proprietary fungicides are now on the market. In making a choice the grower should avoid those for which extravagant

claims are made and should favour those which have been approved by the Ministry (see p. 96).

Bordeaux and Burgundy Mixtures

These are among the most widely used fungicides and are employed for the control of celery leaf spot, tomato blight, etc. The mixtures to be described both contain 1 lb copper sulphate to every 10 gal (i.e., 100 lb) water and are therefore said to be of 1 per cent strength.

A good standard Bordeaux mixture is one containing 4 lb powdered or granular bluestone (copper sulphate) and 5 lb best hydrated lime in 40 gal water. The bluestone should be at least 98 per cent pure, and the hydrated lime (bought in paper bags) should be purchased each season. Burgundy mixture is prepared in the same way, but contains 5 lb washing soda instead of the hydrated lime.

If large quantities of spray are required, it is convenient to prepare a stock solution of bluestone in a wooden tub. Whatever size of tub is used, put in 2 lb bluestone for each gallon of water. Allow plenty of time for the powder or crystals to dissolve and stir well before any of the solution is drawn off.

To prepare 40 gallons of the mixture, run about 30 gal water into a barrel and shake in 5 lb hydrated lime (or washing soda), stirring until thoroughly mixed. Then stir in 2 gal of the stock solution of bluestone and finally make up to the 40-gal mark with water. The liquid is then ready for immediate use.

If only small quantities of spray are required, the amounts to use are:

Bluestone	4 oz
Hydrated lime (or washing soda)	5 oz
Water	2½ gal.

Measure out 2½ gal water into a bucket or other container. A wooden, earthenware or enamelled vessel is best, but a galvanized bucket may be used if it is well washed afterwards. Pour off about a quart of the water into an earthenware or enamelled jug and stir into this the 4 oz bluestone. (Bluestone must never be put into metal vessels unprotected by enamel, because it corrodes them.) While it is dissolving, shake the 5 oz hydrated lime into the water remaining in the bucket and stir well. Finally, when all the copper sulphate has dissolved, slowly pour the blue solution from the jug into the milk-of-lime in the bucket, stirring well all the time. The spray is then ready to apply.

Prepared in this way, the mixtures should be quite safe for use on most plants. To make sure, the bright clean blade of a penknife should be dipped into it for about a minute. If the blade becomes tarnished, more hydrated lime or washing soda must be added. A more sensitive test is to dip a piece of blue litmus paper into the mixture. It should remain blue; if it turns pink, add more hydrated lime or washing soda.

Freshly made Bordeaux and Burgundy mixtures soon deteriorate and should be used the day they are made or at any rate within 24–36 hours. It is best to pour them into the sprayer through a fine gauze strainer or a piece of muslin, to prevent any grit or other impurities from clogging the nozzle. Immediately after use, rinse out with clean water all vessels which have held the spray mixture.

Substitutes for Bordeaux Mixture

Various substitutes for Bordeaux mixture are available, some of which are wettable powders of the "dry Bordeaux" type which simply require the addition of water. These are somewhat less efficient than freshly mixed Bordeaux mixture but save considerable trouble. Colloidal copper fungicides and copper oxychlorides, and cuprous oxide wettable powders are less injurious to certain plants, e.g., tomatoes, than Bordeaux mixture and are particularly useful where a visible spray deposit is objectionable. When used in combination with petroleum emulsions their safety on many plants is increased.

Copper Lime Dusts

Copper lime dusts consist mainly of mixtures of mono-hydrated copper sulphate and hydrated lime. They are applied in the dry state by means of dusting machines or bellows. They are valuable where there is a scarcity of water and have the advantage that they can be put on quickly. They are best applied in the early morning when the foliage is wet with dew. It is generally agreed, however, that they are not as effective as a properly applied wet spray of the Bordeaux mixture type, and therefore more frequent applications are necessary.

Cheshunt Compound

Cheshunt compound is discussed under Control of Damping-off (p. 88).

SULPHUR FUNGICIDES

In the vegetable garden and glasshouse, sulphur fungicides are mainly valuable for the control of powdery mildews and such diseases as tomato leaf mould (p. 72). A number of proprietary compounds have been officially approved.

The finer the particles of the sulphur, the more effective it is as a fungicide and the better it adheres to the plant. Flowers of sulphur, obtained by sublimation, and ordinary ground sulphur are relatively coarse, whereas green sulphur, obtained from coal gas purification, and precipitated sulphurs are finer, and therefore more fungicidal. The finer proprietary sulphur dusts have often a small percentage of inert material, such as kaolin, to prevent the particles from "balling". Sulphur dusts are commonly applied to plants in a dry state by means of a dusting machine, blower or bellows at rates of about 30 lb per acre.

By suitable grinding or by precipitation, colloidal sulphurs are produced. These are of very minute particles and are available in the form of a paste containing about 50 per cent sulphur by weight, which should be mixed with water at the rate of about 3 pt paste per 100 gal water (or 3 fl. oz per 5 gal) for plants grown under glass, or at greater concentration for plants outside.

Liver of sulphur, which was formerly recommended, is too variable in composition to be safe, while solutions of lime-sulphur may injure those types of vegetables which are sensitive to lime.

Sulphur can be deposited on plants in greenhouses in the form of very fine particles by vaporizing it in a sulphur vaporizer and was formerly used for the control of tomato leaf mould. The same principle is utilized in a proprietary electrical apparatus, which vaporizes sulphur very slowly.

ORGANO-SULPHURS

The organo-sulphur compounds, some of which were originally used in rubber manufacture, have had considerable vogue in the U.S.A., and are coming into use in this country. They are usually mild in their effects, do not harden plants as do some of the copper fungicides, and are to some extent specific against certain diseases. When used on fruiting tomatoes some formulations leave an excessive deposit which must be wiped off.

Thiram (tetramethylthiuramdisulphide) is fairly effective against *Botrytis* on tomatoes and other plants when used at high volume or as a dust. It may cause dermatitis if handled excessively, and irritation if inhaled or swallowed.

Zineb (zincethylenebisdithiocarbamate) has given good results against tomato leaf mould either in the form of a spray at high or low volume (the newer formulations leaving less deposit) or as a dust, to be applied at 5–7 oz per 1,000 sq. ft of floor area, and blown into the air, and is promising against *Botrytis* and downy mildews.

Nabam (disodiumethylenebisdithiocarbamate) is used in conjunction with zinc sulphate to give a compound similar to zineb but leaving little deposit. This may be applied at high volume, or at low volume by means of a compressor (p. 94).

Maneb (manganese ethylenebisdithiocarbamate) is used against *Didymella* on tomatoes grown out-of-doors. Some formulations may scorch young plants.

ANTIBIOTICS

Antibiotics, complex organic chemicals derived mainly from soil inhabiting fungi, have proved very valuable in medicine in checking the growth of pathogenic bacteria. Some have uses in plant pathology. Griseofulvin, derived from *Penicillium griseofulvum*, is used against *Botrytis* on lettuce, etc. Streptomycin, derived from *Streptomyces griseus*, is used against various bacterial diseases of plants, e.g., silvering disease of beets and halo blight of dwarf beans, and also against some downy mildews, for example those of brassicas, beets and lettuce.

MISCELLANEOUS FUNGICIDES

Corrosive sublimate (mercuric chloride), a deadly poison, is used for the prevention of club root in brassicas (p. 2) at the rate of 1 part per 2,000 parts of water (1 oz to 12½ gal). It should be handled and used with the greatest care. It will dissolve more easily in hot water, and as it is very corrosive to metallic vessels, the solution should be made and stored in vessels of glass or wood. It is being now replaced by calomel (mercurous chloride) (pp. 3 and 31).

Phenyl mercury salicylate, also poisonous, is used against tomato leaf mould by the aerosol method (p. 95).

Proprietary compounds containing tecnazene (tetrachloronitrobenzene) have given good results. They are in part volatile dusts, most effective in a confined space, such as frames containing lettuces (see Grey Mould of Lettuce, p. 35). They also give good control of corticium damping-off of seedlings of young lettuce and other plants under similar circumstances.

They are used at the rate of about ½ oz per sq. yd and give the best results if the leaves of the seedlings are in a moist condition. They are also used in clamps as sprout depressants and to prevent fungal development. Proprietary materials containing quintozene (pentachloronitrobenzene) are employed as dusts or wettable formulations as bulb dips, and soil treatments against *Rhizoctonia*, *Botrytis*, club root, onion white rot, etc.

Salicylanilide, used in conjunction with a wetter, gives good control of tomato leaf mould (p. 72), if applied early enough. It has also been used successfully against certain powdery mildews. It has the advantage of leaving little visible residue. The product is in the form of a paste which is used at the rate of 3 to 6 oz per 10 gal of water.

Karathane (dinitrocaprylphenylcrotonate), as a suspension or dust, has proved successful against several powdery mildews, although it apparently scorches tomatoes and is injurious to some varieties of chrysanthemums. Karathane smokes are said to be specially effective against cucumber powdery mildew.

Captan (trichloromethylthiotetrahydrophthalimide) is now largely used against apple scab. It has been used successfully in the U.S.A. on tomatoes against blight and other diseases, but it may leave a heavy deposit. It is also used as a spray on various plants, as a seed-bed treatment against damping-off (especially *Rhizoctonia*), and as a protectant against didymella stem rot of tomatoes arising from planting in infested soil.

A chloronitroaniline formulated as a 4 per cent dust is used as a soil disinfectant against *Botrytis* on lettuce, lightly raked into the soil before sowing or planting out.

Formaldehyde is dealt with under Soil Sterilization (p. 83) while cresylic acid is discussed under Cleansing of Glasshouses (p. 95).

SPRAYING AND DUSTING EQUIPMENT

Knapsack Sprayers

Knapsack sprayers are available either as hydraulic machines in which the spray liquid in the 2–3 gallon container is delivered to the nozzle by a diaphragm or plunger pump, lever-operated, as the spraying proceeds, or as pneumatic machines, in which the container is pressurized with air by a hand-operated built-in pneumatic pump. In the latter type the pressure falls as the liquid leaves the container and re-pumping is usually necessary before the container is empty.

Some modern pneumatic knapsack sprayers are charged with air from a detachable pump, and then with liquid under further pressure. These machines are designed to retain the pressurizing air when the spray liquid has been used so that one charge of air is sufficient for several charges of liquid, and the number of pumping operations is reduced.

Low volume air-blast knapsack sprayers are now on the market; these are operated by small petrol engines.

Stirrup Pumps

A simple efficient outfit is a stirrup pump, inserted in a 3 gallon pail and operated from a convenient position. The spray liquid is delivered through a 30 ft length of light ¼ in. bore rubber hose to a light hand lance. Alterna-

tively, the pump can be mounted in a 10–12 gallon galvanized container designed to be lifted with, and transported on, a wheeled tubular steel chassis.

The stirrup pump outfit gives excellent service, its only disadvantage being the necessity for two operators.

Small Power Units

A convenient unit, requiring one operator, consists of a 75–80 c.c. two-stroke petrol engine coupled to a gear pump or a centrifugal pump of 4–6 gal per min capacity at 75 lb per sq. in. and mounted as a unit in a tubular steel frame for protection and ease of carrying. The suction side of the pump is connected to a suction hose with a tubular strainer which is immersed in the fungicide wash in a convenient container. The wash is delivered through 30–120 ft of $\frac{1}{4}$ in. bore light rubber braided hose to a light spray lance.

Large Power Units

Flow pressures above 75 lb per sq. in. are rarely necessary for disease control on vegetable crops, but greater pump throughputs than are possible with small outfits are required for the large-scale spraying of ground crops.

Machines for this purpose are available as tractor trailer or tractor-mounted outfits driven from the power take-off shaft, and consist basically of a 10–15 gal per min gear pump, a 50–100 gal tank and multiple-nozzle "gate" booms. These machines can be adapted for lance spraying by the attachment of light hose and spray lances.

Pressures of 200–300 lb per sq. in. with outputs of 2–3 gal per min may be required for routine cleansing, particularly of the highest parts of glasshouses. A suitable outfit for this purpose is a plunger pump coupled to an engine and mounted on a four-wheeled trolley or two-wheeled trailer. The wash is delivered through high pressure hose to a spray gun. The flow pressure can be reduced to 75 lb per sq. in. by adjustment of the relief valve when the outfit is required for normal crop spraying with light hose and lance.

Light Spray Lances

The most convenient crop spraying lance for most purposes consists of a small trigger tap with a built-in filter unit to which is attached a brass or rigid plastic tube about 30 in. long. A brass adaptor at the end of this tube accommodates the small brass swirl or ceramic flat spray nozzle. A 35–45 degree bend at the nozzle end of the tube facilitates manipulation, particularly for underleaf spraying.

Spray Application

Inefficient application of the spray material is one of the most frequent causes of failure to control diseases.

The most consistent and reliable results are obtained when the crop plant is completely wetted by the spray material, which should therefore contain an efficient wetting agent compatible with the fungicide.

Many fungicides must be agitated continuously to keep them in suspension.

Regular cleaning of the equipment, particularly the filters, is essential for efficient spraying.

Other Methods of Application

Insufficient information is available at present for firm recommendations to be made on the control of vegetable diseases (as distinct from potatoes) by

small (low) volume spraying. Tractor-mounted row-crop machines are designed to apply 20-30 gal of liquid per acre instead of the 80–120 gal, usually applied by large (high) volume machines.

There are also air-blast low volume sprayers mounted on wheels for row-crop work.

Two alternative methods of fungicide application in glasshouses are smokes and the fine atomization of liquids to form aerosols. Aerosol generators may take the form of special containers in which the spray liquid is pre-pressurized with an inert gas and is emitted as a cloud of fine droplets when the release valve is operated. Other methods employ machines for the atomization of the liquid through compressed air nozzles or by a high speed spinning disc.

Fungicide dusting is generally less efficient than spraying for the control of plant disease. Small-scale applications may be made by shaking the dust from a muslin bag, or from a simple bellows duster. Hand-operated rotary dusters incorporating a high-speed blower or a lever-operated knapsack machine are also available. For large-scale work power-operated dusting machines may be used. Compressed-air operated dust guns or motorized dust bellows are frequently used in glasshouses.

CLEANSING OF GLASSHOUSES

Glasshouses should be cleared of plants at least once a year and thoroughly cleansed with a 2 per cent formalin solution (1 pt to 6 gal water) with addition of a wetter. Goggles should be worn. All the sides, floors, benches and pipes should be made thoroughly wet, starting at the end furthest from the door. This can be done by means of a spraying machine, placing the nozzle near the surface to be sterilized. The house should then be closed for a day and the temperature raised to about 70°F. It should then be aired thoroughly for about 14 days until the smell has disappeared. Formalin is effective, for instance, in killing airborne spores of *Didymella*.

Where insect pests have been troublesome in addition to diseases, the glasshouse may be sprayed with emulsified cresylic acid compounds. Several proprietary preparations are on the market. The makers' instructions should be followed carefully. The emulsion should be applied in the same way as suggested for formalin, i.e., by means of a spraying machine with the nozzle held close to the walls, etc. All the interior should be drenched and the ridge should then be sprayed from the outside. The operator should wear goggles to protect his eyes. When the house has been treated it should be closed for several days.

For cleansing glasshouses at the end of the season, or when they are empty, sulphur can be used as a fumigant, at the rate of 4 lb sulphur per 10,000 cu. ft of space. The sulphur should be distributed in small heaps on pieces of wood wool, which are then ignited. The operation should take place in a dry atmosphere to prevent interaction with metal and zinc paint. If tomato plants are badly affected with leaf mould or stem rot at the end of the season the sulphur may be burned in the houses before the plants are removed. Ventilators and doors should be closed tightly for 2 to 3 days afterwards and precautions taken to prevent the fumes from reaching neighbouring plants.

Official approval has been granted in the Agricultural Chemicals Approval Scheme to a number of proprietary brands of several of the fungicides and herbicides mentioned in this bulletin. In future, approval will be indicated on the containers by the mark shown here, which is replacing the diamond crown mark of the Crop Protection Products Approval Scheme. It is recommended that approved products be used. A list of products approved in the Agricultural Chemicals Approval Scheme will be published in February each year, commencing in 1961, and may be obtained free of charge on application to the Ministry of Agriculture, Fisheries and Food (Publications), Ruskin Avenue, Kew, Richmond, Surrey.

Appendix

Other publications on vegetable diseases and allied subjects issued by the Ministry.

BULLETINS

Soil Sterilization	No. 22	4s. od.	(4s. 4d.)
Outdoor Salad Crops	No. 55	3s. 6d.	(3s. 11d.)
Tomatoes	No. 77	5s. 6d.	(5s. 11d.)
Watercress Cultivation	No. 136	2s. 6d.	(2s. 10d.)
Sugar Beet Diseases	No. 142	7s. 6d.	(7s. 11d.)
Salad and Other Food Crops in Glasshouses	No. 143	4s. od.	(4s. 5d.)

Bulletins are obtainable from H.M. Stationery Office at any of the addresses on the back cover page, or through any bookseller at the prices quoted above. Prices in brackets include postage.

ADVISORY LEAFLETS

Cabbage Root Fly	No. 18
Mosaic Disease and Streak of Tomato	No. 38
Tomato Verticillium Wilt	No. 53
White Rot of Onions and Related Crops	No. 62
Carrot Fly	No. 68
Onion Downy Mildew	No. 85
Turnip Gall Weevil	No. 196
Tomato Spotted Wilt	No. 238
Leaf Spot of Celery	No. 241
Onion and Leek Smut	No. 261
Tomato Leaf Mould	No. 263
Sclerotinia Disease of Potatoes	No. 265
Potato and Tomato Blight	No. 271
Club Root	No. 276
Soil Sterilization	No. 319
Sugar Beet Yellows	No. 323
Cucumber Mosaic	No. 340
Violet Root Rot	No. 346
Cauliflower Mosaic	No. 370
Stem and Bulb Eelworm on Vegetables	No. 440

Advisory Leaflets are priced at 3d. each (5d. by post).
Single copies, up to a total of six different leaflets, are obtainable free from the Ministry of Agriculture (Publications), Ruskin Avenue, Kew, Richmond, Surrey. Copies in excess of this number must be obtained from H.M. Stationery Office.

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Printed in England under the authority of Her Majesty's Stationery Office
by James Townsend & Sons Ltd.

(B.22900) Ps.504859 Wt.2579/3888 K40 3/61 J.T.S.Ltd 327

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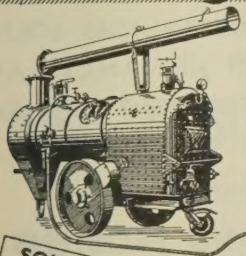

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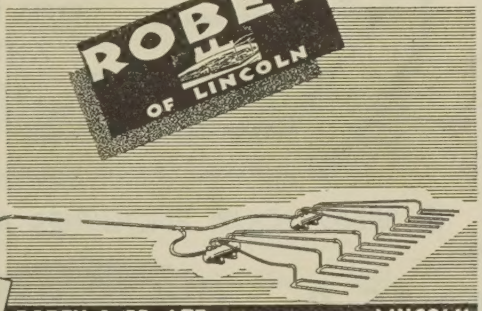

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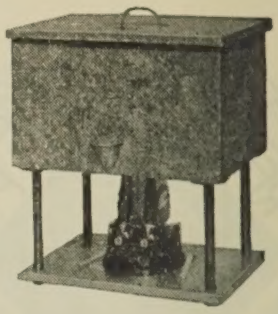

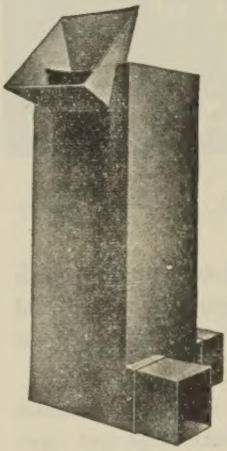

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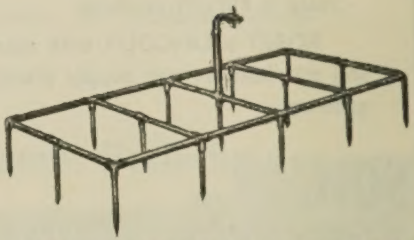

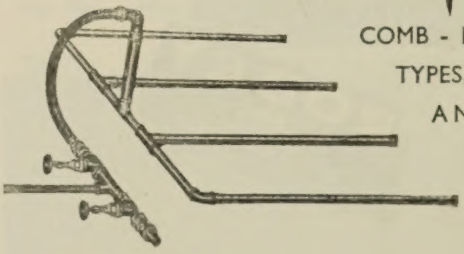

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